

FAUQUIER COUNTY WATER AND SANITATION AUTHORITY

MICROFILTRATION SYSTEM FOR THE BEALETON WATER TREATMENT FACILITY

Contract No. 14-E-02-0203

INVITATION FOR BID

Notice is hereby given that separate sealed bids for a Microfiltration System for the Bealeton Water Treatment Facility will be received from qualified Contractors by the Fauquier County Water and Sanitation Authority on April 17, 2014 until 2:00 p.m. Eastern Standard Time, at which time they will be publicly opened and read aloud.

Bid Documents may be obtained in the Administrative Offices of the Fauquier County Water and Sanitation Authority, 7172 Kennedy Road, Warrenton, VA 20187, on the FCWSA website (www.fcwsa.org), or by calling (540) 349-2092.

The FCWSA reserves the right to accept or reject any or all bids, to waive irregularities and to award the Contract as it deems will best serve its interest.

FAUQUIER WATER AND SANITATION AUTHORITY

Microfiltration System for the Bealeton Water Treatment Facility

Contract No. 14-E-02-0203

INSTRUCTIONS TO BIDDERS

Bids will be received by the Fauquier County Water and Sanitation Authority (the "Authority") at the office of the Authority, 7172 Kennedy Road, Vint Hill Farms, Warrenton, Virginia 20187-3907, until 2:00 p.m. local time, April 17, 2014 at which time they will be publicly opened and read aloud. Bids received after the stated deadline will be discarded.

Each Bid must be submitted in a sealed envelope, addressed to:

Fauquier County Water and Sanitation Authority
Attn: Terry Reed, Contracts Administrator
7172 Kennedy Road
Vint Hill Farms
Warrenton, VA 20187-3907

Each sealed envelope containing a Bid must be plainly marked on the outside as follows:

- A. Microfiltration System for the Bealeton Water Treatment Facility
- B. Contract No. 14-E-02-0203
- C. The Name of the Bidder
- D. The Address of the Bidder
- E. The Due Date: 14 April 2014
- G. The Time of the Bid Opening: 2:00 P.M.
- H. A Statement That: "This Container is Not To Be Opened Prior To The Bid Opening"

Should any Bid be received which is not so identified, the Bidder assumes the risk that the submission will be opened prior to Bid Opening. Bids so opened shall be disqualified. If forwarded by mail, the sealed envelope containing the Bid must be enclosed in another envelope addressed to the Authority.

For technical information contact Ms. Mary C. Sherrill, Director of Engineering at (540) 349-2092.

All bidders must initial and return Bid Specifications - Exhibit A. All Bids must be made on the required Bid Proposal form (Exhibit B). All blank spaces for Bid Prices must be filled in, in ink or typewritten, and the Bid must be fully completed and properly executed when submitted. Only one copy of the Bid Proposal form and supporting documents is required to be submitted.

The Authority in its sole discretion may waive any informalities or minor defects and reserves the right to reject any and all Bids. Any Bid received after the time and date specified shall not be considered. Any Bid may be withdrawn prior to the scheduled time and date for the opening of the Bids or any authorized postponement thereof. No Bidder may withdraw a Bid within sixty (60) days after the actual opening thereof unless the Bidder follows Procedure (i) as specified in Section 11-54.A of the Code of Virginia 1950, as may be amended. Should there be reasons why the contract cannot be awarded within the sixty-(60) day period, the time may be extended by mutual agreement between the Authority and the Bidder.

Proposals will be compared on the basis of total Bid Price.

All bids must satisfy the technical specifications of Exhibit A - Section 11250, Microfiltration System Specifications. Appendix A specification documents are for reference purposes only.

FAUQUIER COUNTY WATER AND SANITATION AUTHORITY

Purchase of Microfiltration System for the Bealeton Water Treatment Facility Contract No. 14-E-02-0203

PURCHASE AGREEMENT

THIS AGREEMENT, made the _____ day of April 2014, by and between the **FAUQUIER COUNTY WATER AND SANITATION AUTHORITY**, a public body politic and corporate (hereinafter called the "Authority"), and _____
_____(hereinafter called the "Vendor"), recites and provides as follows:

RECITALS

WHEREAS, the Authority wishes to purchase from the Vendor a microfiltration system and related services (the "Goods and Services") and the Vendor wishes to provide such Goods and Services, all on the terms and conditions set forth herein in an amount not to exceed \$_____.

AGREEMENT

NOW THEREFORE, in consideration of the premises contained herein, and intending to be legally bound, the Authority and Vendor hereby agree as follows:

1. Goods and Services

The Vendor shall provide the Goods and Services as set forth in Exhibit "A" - Bid Specifications and shall provide all personnel, equipment, materials, and transportation services required in connection therewith. The specific Goods and Services purchased by the Authority will be defined by the Bid Specification included with this Agreement.

2. Price and Charges

The Vendor shall provide the Goods and Services for \$_____ and set forth in Exhibit "B" - Bid Prices and Proposals which is a complete deliverable and ready for the Authority's use, including all applicable freight, delivery, and handling charges. The Vendor hereby acknowledges that extra charges will not be allowed. The Vendor agrees to hold pricing firm for a period of one hundred eighty (180) days from date of bid opening.

3. Delivery Date

The Goods shall be delivered as set forth in Exhibit "B" - Bid Price and Proposals. The Vendor shall contact the Authority forty-eight (48) hours prior to delivery so that appropriate personnel are on hand to receive delivery. The Services shall be provided according to a schedule that is mutually acceptable to the Authority and the Vendor.

4. Testing and Inspection

The Authority reserves the right to conduct any test and/or inspection it may deem advisable to assure Goods and Services conform to the specifications as set forth in Exhibit "A" - Bid Specifications.

5. Taxes

The Authority is exempt from all direct Federal and State taxes. Tax Certificate of Exemption forms will be issued upon request. All deliveries under this Agreement shall be free of Federal excise and transportation taxes.

6. Invoices

Invoices for Goods and Services ordered, delivered and accepted, shall be submitted by the Vendor directly to the payment address shown on the Purchase Order. All invoices shall show the Authority Purchase Order Number.

7. Payment Terms

Payment will be made forty-five (45) days after receipt of a proper invoice, or forty-five (45) days after receipt of all goods or acceptance of work, whichever is the latter.

8. Payment to Subcontractors

The Vendor is hereby obligated to pay any and all subcontractor(s) within seven (7) days of the Vendor's receipt of payment from the Authority for the proportionate share of the payment received for work performed by the subcontractor(s) under this agreement.

9. Assignment of Contract

The Vendor shall not assign, transfer, convey, sublet, or otherwise dispose of this Agreement or of its right, title, or interest therein, or of the power to execute such Agreement, to any other person, firm or corporation without the prior written consent of the Authority. In no case shall such consent relieve the Vendor from its obligations or change the terms of this Agreement.

Subject to the foregoing, this Agreement shall be binding upon, and inure to the benefit of, each of the parties hereto, and their respective successors and assigns.

10. Nondiscrimination in Hiring Practices

During the performance of this Agreement, the Vendor agrees as follows:

- A. The Vendor will not discriminate against any employee or applicant for employment because of race, religion, color, sex, or national origin, except where religion, sex or national origin is a bona fide occupational qualification reasonably necessary to the normal operation of the Vendor. The Vendor agrees to post in conspicuous places, available to employees and applicants for employment, notices setting forth the provisions of this nondiscrimination clause.
- B. The Vendor, in all solicitations or advertisements for employment placed by or on behalf of the Vendor, will state that such Vendor is an equal opportunity employer.
- C. Notices, advertisements and solicitations placed in accordance with federal law, rule or regulation shall be deemed sufficient for the purpose of meeting the requirements of this Article.

The Vendor shall include the provisions of Article 13, Paragraphs A, B and C, herein, in every subcontract or purchase order in connection with the Goods and Services in amounts equal to or exceeding \$10,000, in order that the foregoing provisions will be binding upon each subcontractor or vendor.

The Vendor certifies that the Vendor does not and will not during the performance of this Agreement violate the provisions of the Federal Immigration and Reform Act of 1986, which prohibits the employment of illegal aliens.

11. Ethics in Public Contracting

The provisions contained in §§ 11-72 through 11-80 of the Virginia Public Procurement Act, as set forth in the 1950 Code of Virginia, as amended, is applicable to all contracts solicited or entered into by the Authority. The Vendor certifies that its bid was made without collusion or fraud and that it has not offered or received any kickbacks or inducements from any other vendor, supplier manufacturer or subcontractor in connection with its bid, and that it has not conferred any public employee having official responsibility for this procurement transaction any payment, loan, subscription, advance, deposit of money, services or anything of more than nominal value, present or promised, unless consideration of substantially equal or greater value was exchanged.

12. Anti-Trust

By entering into this Agreement, the Vendor conveys, sells, assigns, and transfers to the Authority all rights, title and interest in and to all causes of the action it may now have or hereafter acquire under the antitrust law of the United States, the Commonwealth of Virginia and the County of Fauquier, relating to the particular Goods and Services purchased or acquired by the Authority under this Agreement.

13. Termination

The Authority, at its sole discretion, may terminate this Agreement, should the Goods and Services fail to conform to the specifications as set forth in Exhibit "A" - Bid Specifications, upon forty eight (48) hours written notice to the Vendor. In the event of termination under this Article, the Vendor shall receive compensation for all Goods received and accepted and/or all Services satisfactorily completed through the date of such termination.

14. Disputes

Contractual claims (whether for money or for other relief) shall be submitted in writing to the General Manager of the Authority no later than sixty (60) days after final payment; provided, however, that written notice of the Vendor's intention to file such claim must be given at the time of occurrence or beginning of the portion of the Services upon which the claim is based, whichever occurs later. A written decision upon any such claim will be made by the General Manager of the Authority within sixty (60) days after submittal of the claim.

The Vendor may not institute legal action prior to receipt of the General Manager's decision on the claim, unless the General Manager fails to render such decision within one hundred and twenty (120) days after submittal of the claim. The decision of the General Manager shall be final, unless the Vendor initiates legal action as provided in § 11-70 of the 1950 Code of Virginia, as amended. Failure of the General Manager to render a decision within one hundred and twenty (120) days shall not automatically result in the Vendor being awarded the relief claimed, nor shall it automatically result in any other relief or penalty. The sole result of the General Manager's failure to render a decision within the time allocated shall be the Vendor's right to immediately institute legal action. No administrative appeal procedure pursuant to § 11-71 of the 1950 Code of Virginia, as amended, has been established for contractual claims under this Agreement.

15. Notices

All notices hereunder shall be in writing, shall be given either manually or by mail and shall be deemed sufficiently given when actually received by the party to be notified or when mailed, if mailed by certified or registered mail, postage prepaid, addressed to such party at his address set forth below. Any party may, by notice to the other parties given in the manner provided for herein, change his or its address for receiving such notices.

Address for notices to the Vendor:

Address for notices to the Authority:

Mr. Philip "Butch" Farley, General Manager
Fauquier County Water and Sanitation Authority
7172 Kennedy Road
Warrenton, VA 20187-3907

16. Indemnity by the Vendor

The Vendor shall indemnify and hold harmless the Authority (its members, officers, employees and authorized representatives) from and against any breach of any representation or warranty, or any loss, damage, expense or liability to the extent arising from the willful misconduct or negligent act, error or omission of the Vendor or of the Vendor's subcontractors or subconsultants, if any, in the provision of the Goods or the performance of the Services contemplated by this Agreement.

17. Governing Law; Venue

This Agreement shall be construed and performed in accordance with the laws of the Commonwealth of Virginia, without reference to conflict of law principles. Resolution of any outstanding claims, counterclaims, disputes and other matters arising out of or in connection with this Agreement shall be decided in a court of competent jurisdiction in the Commonwealth of Virginia; provided that nothing contained herein shall vitiate the finality of the General Manager's decisions pursuant to Article 14 of this Agreement.

18. Entire Agreement

This Agreement constitutes the entire agreement of the parties relating to its subject matter and supersedes all prior and contemporaneous agreements of the parties in connection herewith.

19. Prohibition of Contingency Fees

The Vendor warrants that it has not employed any company or person other than a bona fide employee working for the Vendor to solicit or secure this Agreement and that it has not paid or agreed to pay any person, company, corporation, individual or firm, other than a bona fide employee working solely for the Vendor, any favor, commission, percentage, gift, or any other compensation contingent upon or resulting from the award or making of this or any other agreement relating to the Goods and Services. In the event of breach of this provision, the Authority shall have the right to terminate this Agreement with the Vendor without liability and, in its discretion, to deduct from amounts due under this Agreement, or otherwise recover, the full amount of such fee, commission, percentage gift or consideration, as well as the cost of such recovery, including, without limitation, reasonable attorney's fees and costs.

20. Cumulative Rights

The rights and remedies provided in this Agreement shall not be exclusive, but shall be cumulative and in addition to all other rights and remedies provided by applicable law, including but not limited to statutory or common law indemnity, contribution, or other remedy at law or in equity.

21. Waiver Not Continuing

The waiver by either party of any failure on the part of the other party to perform any of its obligations under this Agreement shall not be construed as a waiver of any future or continuing failure or failures, whether similar or dissimilar thereto.

22. Surviving Obligations

The representations, warranties and covenants of the parties shall continue after and survive, and be enforceable notwithstanding, the execution of this Agreement, the completion of the provision of the Goods and Services or the expiration or other termination of this Agreement.

23. Captions

The captions in this Agreement are for purposes of convenience only and form no substantive part of this Agreement. In no event shall they be deemed to limit or modify the text of this Agreement.

[The Remainder of This Page is Deliberately Left Blank]

IN WITNESS WHEREOF, the parties hereto have made and executed this Agreement as of the day and year first above written.

AUTHORITY:

FAUQUIER COUNTY WATER AND SANITATION AUTHORITY

ATTEST: _____

BY: _____

Philip "Butch" Farley
General Manager

VENDOR:

ATTEST: _____

BY: _____

Attachment: Exhibit "A" - Bid Specifications
Exhibit "B" - Bid Prices and Proposal

The bidder shall initial and return Exhibit "A". Failure to do so may result in the disqualification of your bid.

EXHIBIT "A"

**Purchase of Microfiltration System for the Bealeton Water Treatment Facility
Contract No. 14-E-02-0203**

BID SPECIFICATIONS

The bidder shall furnish a microfiltration system in accordance with the specifications attached. The equipment supplied will be new and unused except for any necessary testing and transportation. Equipment other than new or current year model shall not be considered as responsive to these specifications. All components, unless otherwise required by these specifications, shall be standard or optional equipment specifically advertised and installed by the manufacturer. The bidder is responsible to insure that all structural components are of adequate size and/or rating to perform as specified.

The bidder shall include the manufacturer's literature describing the equipment being offered. All equipment asked for in these specifications must conform to State of Virginia laws where applicable.

SECTION 11250
MICROFILTRATION SYSTEM SPECIFICATIONS

PART 1 - GENERAL

1.1. SCOPE OF WORK

- A. Furnish microfiltration system to filter groundwater for drinking water supply.
- B. The microfiltration system shall be a complete package, primarily skid mounted, containing pressure driven semi-permeable hollow fiber membranes, pumps, manual & automated valves, tanks, instruments, pre-filters, control system, and on-skid piping, wiring, conduit, and tubing for a fully operational system.
- C. The microfiltration equipment shall be capable of removing particulate matter from the water, including :
 - 1. Turbidity
 - 2. Arsenic (oxidized)
 - 3. Giardia and Cryptosporidium
 - 4. Microorganisms (bacteria)
 - 5. Viruses
 - 6. Iron and Manganese (oxidized)
- D. The microfiltration system shall meet all requirements of the Virginia Department of Health Working Memo #880 revised September 14, 2012.

1.2. QUALITY ASSURANCE

- A. Quality Standards. The microfiltration system manufacturer shall be currently certified as a supplier to meet quality standards as defined by International Standards Organization (ISO) standard 9001.
- B. Microfiltration System Warranty: The manufacturer shall warrant the entire system against failure of any component due to material or workmanship for a period of 12 months after installation, testing and startup of the system or 18 months from delivery, whichever occurs first. Membranes shall be warranted for a minimum 10 years with full replacement value during the first 3 years and pro-rated replacement value for 7 years after the first 3 years.
- C. Fiber Breakage Warranty: The manufacturer shall warrant the membrane hollow fibers against excessive breakage. If any single module has more than twenty (20) fibers break within the first 7 years (84 months) of operation, that module shall be deemed defective and be replaced free of charge with a new replacement module. All modules supplied to replace defective modules shall be supplied

with its own 7 years (84 months) fiber breakage warranty which shall begin upon the date of installation.

D. Service and Support: The microfiltration system manufacturer shall have the ability to provide the following services and contracts:

1. Start-up/commissioning assistance
2. Telephone support available 24 hours per day, 7 days per week
3. Remote or on-site occasional system status monitoring
4. On-site troubleshooting and repair for equipment/process
5. Operator Training
6. Maintenance Contracts (Equipment and CIP procedures)

E. FACTORY ACCEPTANCE TESTING (FAT)

1. The microfiltration system shall be fully tested prior to shipment to assure that the system components will be fully functional when properly installed at the site. The testing shall include:
 - a. Instrument operation and calibration verification of on-skid equipment.
 - b. Check operation of all on-skid pumps, valves, strainer, etc.
 - c. Process testing, including running water through the system to verify operations and check for leaks.
 - d. Verify that equipment supplied matches approved P&ID and electrical drawing.
 - e. Verify alarms and alarm display.
 - f. Verify that the system programming follows the System Functional Description.

1.3. REFERENCES

A. This section contains references to the following industry and trade group standards. They are a part of this section as specified and modified. The latest version of the standard references shall apply. In case of conflict between the requirements of this section and those of the listed documents, the more stringent requirements shall prevail.

<u>Reference</u>	<u>Title</u>
ASME/ANSI	International Boiler and Pressure Vessel Code
ASME/ANSI B16.5	Pipe Flanges and Flanged Fittings

ASME/ANSI B36.19	Stainless Steel Pipe
ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A666	Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM/ANSI A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM D-1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D 6908-03	Standard Practice for Integrity Testing of Water Filtration Membrane Systems
AWS D1.1	Structural Welding Code for Steel
ISO 9001	Quality Management System
NEMA MG1	Motors and Generators
NFPA 70	National Electrical Code
NFPA 79	Electrical Standard for Industrial Machinery
SSPC-SP10	Near-White Blast Cleaning
UL 508A	Industrial Control Panels

1.4. SUBMITTALS

A. Drawings. Submit within two (2) weeks of receipt of purchase order, drawings showing the overall dimensions including anchoring baseplate dimensions, equipment pad sizes and center lines, piping and wiring interface points, and the location of equipment required to be accessed during normal operation of the system. Unless otherwise specified, these drawings are to be provided for information. Submittal drawings shall include:

1. P&ID
2. General Arrangement Drawings for Manufacturer-Supplied Equipment
3. Electrical Interconnect Drawing (Power One-Line, I/O Interconnection, and Network Layout)
4. Electrical Drawings for Manufacturer-Supplied Panels
5. Mechanical Replacement Parts List
6. Electrical Replacement Parts List

7. Compressed Air System Information
8. AP Skid Installation Manual
9. Cutsheets for Manufacturer-Supplied Off-Skid Components
10. Installation & Startup Checklist

B. Installation, Operation, and Maintenance Manual. At time of equipment shipment, submit an Installation, Operation, and Maintenance (IOM) manual and Software License Transfer Documentation with the equipment. The IOM shall be printed in black and white onto 20 lb copy paper and placed in a sturdy 3 ring binder with tabulated index, and clear plastic pockets for drawings. Provide one hard copy and six (6) electronic copies on separate, labeled, CD's. The IOM manuals shall include detailed component information for off-skid equipment only (provided electronically on a submittal CD), and recommended replacement parts list.

C. Project References. Submit project references for similar systems operating in similar applications, including utility or District name, address, phone number, name of contact person and date of installation.

1.5. SERVICE CONDITIONS

- A. Location: Town of Bealeton, Fauquier County, Virginia.
- B. Raw water source: Groundwater from wells.
- C. Site elevation: 289 feet above mean sea level.
- D. Environment: Microfiltration equipment will be installed indoors in a dry environment.
- E. Temperature: Indoor temperature maintained between 35° F and 98° F.

1.6. PERFORMANCE REQUIREMENTS

- A. Filtration Rate: Microfiltration equipment shall be designed to operate at a maximum flux rate of 45 gpd/sf (GFD) of membrane surface.
- B. Giardia and Cryptosporidium: The microfiltration equipment shall be capable of achieving a 6-log reduction of Giardia and Cryptosporidium cysts and oocysts at the specified maximum filtrate flow rate.
- C. Turbidity: The equipment shall be capable of achieving filtrate turbidity values of 0.1 nephelometric turbidity units (NTU) or less at the specified maximum flow rate under normal operating conditions.
- D. Microorganisms. The microfiltration equipment shall be capable of removal of microorganisms.
- E. Viruses. The microfiltration equipment shall be capable of 0.5-log removal of MS2 coliphage or bacteriophage with no coagulation process upstream of the

microfilters, and 2.5-log removal of MS2 coliphage or bacteriophage with coagulation process upstream of the microfilters.

F. Water Recovery: The microfiltration system shall be capable of operating with a minimum water recovery efficiency (ratio of filtrate produced/raw water used) of 95 percent for drinking water.

G. Backwash and CIP Wastewater: Spent backwash water and CIP wastewater shall be discharged to a sanitary sewer. CIP wastewater shall be discharged to a PVC sanitary sewer without neutralization.

1.7. FULLY AUTOMATED PROCESSES

A. The microfiltration system shall include all equipment and controls for automated operation of the system in the following modes.

1. FILTRATION

The filtration mode (normal mode) of operation shall allow the operator to preset the desired flow rate for clean water production. The system will automatically adjust the raw water pump speed to deliver this preset water flow rate from the system. The system control shall also be configured to vary production rate based on the availability of raw water upstream of the system, or run to maintain a level in a collection clear well downstream of the system. If the system is empty, the system will perform an automated fill/vent procedure. The system will display alarm conditions on the HMI, notifying the operator of any abnormal conditions.

2. REGENERATION/FLUX MAINTENANCE

Regeneration or flux maintenance shall automatically occur at an adjustable preset time or volume of water processed interval. The flux maintenance sequence shall be fully automated and require no intervention by an operator. The flux maintenance sequence shall inject compressed air to assist in removal of solids from the hollow fiber membranes and continuous backflow of permeate water through the membranes to eliminate the filtered solids from the system. The modules shall then be flushed to remove any remaining solids and air bubbles through a selectable feed side rinse using raw water or a backwash with filtrate. The system shall alarm the operator of abnormal conditions that would prevent the system from entering the regeneration cycle. The entire flux maintenance procedure shall require no more than two minutes.

3. INTEGRITY TEST

The microfiltration system shall be capable of direct integrity testing (DIT) using a pressure hold method operating at a minimum pressure of 25 psig. Direct integrity testing (DIT) must be performed in accordance

with ASTM D 6908-03. Testing must be fully automated and shall not require operator intervention unless a failure is detected. The integrity test must be capable of detecting a defect that will allow an LRV (log reduction value) of 3.5 or higher. If the DIT fails, the system must automatically alarm and be capable of shutting the system down on failure. If a failure occurs, the operator shall be able to easily and quickly identify the defective module by pressurizing the modules with air and observing bubbles in the clear coupling at the exit of the modules. The microfiltration system shall allow the operator to easily detect the defective module without special equipment that requires every module to be individually tested (such as sonic testing) or requiring the module to be removed from the system. A defective module shall be capable of being repaired and returned to service in 30 minutes or less and shall not require full removal of the module from the system. If removal of a module is required, the module space shall be capable of being easily sealed off and allow the system to be returned to service using the remaining modules.

1.8. SEMI-AUTOMATED PROCEDURES

A. CHEMICAL CLEAN-IN-PLACE

The microfiltration system shall automatically notify the operator when to chemically clean the membranes based on an increase in trans-membrane pressure, or at a preset duration since the last clean-in-place (CIP) was performed, whichever occurs first. The CIP process will be semi-automated which will require the operator to perform certain operations. The microfiltration system controller shall guide the operator through a detailed sequence of steps to assure that the CIP is properly performed. The actions required by an operator during the CIP procedure include:

1. Perform the CIP procedure as defined by the system controller.
2. Manually open or close some valves fully to prepare the system to perform the CIP procedure.
3. Assure that adequate warm water is available for the CIP procedure. Manually open a valve to fill the CIP chemical tank with water.
4. Add prescribed amount of chemical solution to the CIP chemical tank.
5. Start the automated CIP recirculation cycle/rinse at the microfilter control panel.
6. Repeat the preceding steps for the second cleaning cycle.
7. Perform the final rinse routine and return the system to service.

PART 2 - PRODUCTS

2.1 REQUIRED EQUIPMENT

<u>Equipment</u>	<u>Equipment Numbers</u>
Microfilter 1	MF 1
Microfilter 2	MF 2
Chemical, Hot Water, Neutralization System 1	CHN 1

2.2 ACCEPTABLE MANUFACTURERS

- A. Model AP-4 microfiltration units as manufactured by Pall Corporation of Cortland, New York, or Engineer-approved equal.
- B. Acceptable manufacturers shall have experience supplying membrane filtration systems that have been in continuous use in the State of Virginia for no fewer than five (5) years or in continuous use in the United States for no fewer than ten (10) years.
- C. Acceptable manufacturers shall have no fewer than five (5) installations operating in the State of Virginia for more than one (1) year which are of similar design in both system and membrane module to the proposed alternative microfiltration system.
- D. Microfiltration system shall have prior pre-approval for use in the State of Virginia by the Virginia Department of Health.
- E. If alternative equipment is proposed, demonstrate to the Engineer and Owner that all requirements of materials, performance, and workmanship will be met or exceeded by the proposed equipment. If alternative equipment is proposed and acceptable to the Engineer and Owner, the Contractor shall be responsible for all costs incurred by Engineer and Owner for system evaluation and design modifications or redesign, including electrical, mechanical, structural and civil elements of the installation.

2.3 EQUIPMENT FEATURES

- A. Microfiltration system shall include the following features as a minimum:
 1. Feed and Reverse Flush (RF) tanks with level instruments
 2. Feed/recirculation pump with on-skid VFD
 3. Reverse Flush (RF) pump with on-skid VFD
 4. On skid automatic backwashing pre-filter
 5. Pressure transmitters for pre-filter and membrane pressure differential measurement
 6. Temperature transmitter

7. Filtrate/backwash flow transmitter
8. Modulating raw water level control valve on inlet to feed tank
9. Microfiltration module rack and associated piping
10. Fully wired control panel with HMI and PLC to provide automation
11. Fully automated Integrity Test system
12. Fully automated air scrub/backwash system
13. Semi-automatic Clean In Place (CIP) system
14. All piping, valves, wiring, supports, and associated equipment to provide a fully functional system.
15. Turbidimeters (on-skid)
16. Enhanced Flux Maintenance (EFM) skid
17. Automated CIP Chemical Transfer system
18. Uninterruptible Power Supply (UPS)
19. Modem/PC for remote access and data trending

2.4 MEMBRANES

- A. Microfilter membranes shall be hollow fiber with 0.1 micron pore size rating capable of high and stable flux rates. Membranes shall be high-crystalline PVDF (Polyvinylidenefluoride) constructed with advanced bonding techniques to provide an exceptionally strong module.
- B. Microfilter membranes shall be configured for a normal filtration flow from outside the hollow fiber membranes through to the inside (lumen) of the fiber.
- C. Membranes and module shall be compatible with the following cleaning and treatment chemicals at the concentrations indicated.

Chemical	Formula	Maximum Concentration	
Sodium hypochlorite	NaOCl	5000	ppm
Sodium hydroxide	NaOH	4	percent
Nitric acid	HNO ₃	10	percent
Hydrochloric acid	HCl	10	percent
Sulfuric acid	H ₂ SO ₄	10	percent
Citric Acid	C ₆ H ₈ O ₇	20	percent
Oxalic Acid	H ₂ C ₂ O ₄	2	percent
EDTA	C ₁₀ H ₁₆ N ₂ O ₈	0.4	percent
Hydrogen Peroxide	H ₂ O ₂	2	percent
Potassium permanganate	Na/KMnO ₄	10	ppm
Chlorine dioxide	ClO ₂	0.2	ppm

- D. Membrane and module shall be compatible with the following coagulants:

1. Alum (Aluminum Sulfate)
2. PACl (Polyaluminum Chloride)
3. ACH (Aluminum Chlorohydrate)
4. FeCl₃ (Ferric Chloride)
5. Fe₂(SO₄)₃ (Ferric Sulfate)

2.5 MEMBRANE MODULES

- A. Membrane modules shall consist of hollow fiber membranes encased in a cylindrical housing fabricated of Acrylonitrile-Butadiene-Styrene (ABS) copolymer.
- B. Membrane filtration flux rate, maximum: 45 gpd/sf (gfd)
- C. Membrane filter surface area, minimum: 538 sf per module
- D. Membrane module operating pressure, maximum: 45 psig
- E. Membrane module operating temperature, maximum: 104⁰ F
- F. The modules shall be constructed as an integral unit, without mechanical seals such as o-rings and gaskets, to eliminate risk of raw water bypass to the filtrate side of the membrane.
- G. Each module shall be able to be manually removed from the membrane rack without requiring any lifting mechanisms.
- H. Microfilter system shall design shall provide space for at least two future membrane modules per module rack to allow reduced flux rates if desired for optimum performance.

2.6 PRE-FILTER

- A. Microfilter system shall include an on-skid automatic self-cleaning strainer to protect the membranes from particles that may cause damage. The strainer backwash shall be initiated by meeting a differential pressure setpoint, or by a specified time interval, which ever comes first.

Type:	Auto-Hydraulic
Manufacturer:	Amiad SAF3000
Screen Size:	300 Micron
Body:	Painted Carbon Steel
Wetted Parts:	Stainless Steel, NSF approved internals
Gaskets:	EPDM
Lubrication:	Synthetic Grease

2.7 PRETREATMENT SYSTEM

- A. Pretreatment system shall be provided by Contractor per Drawings to remove iron, manganese, and arsenic by chemical precipitation. Pretreatment system shall consist of an in-line rapid mixer, chemical metering pumps, and minimum contact time of 2 minutes in the raw water pipeline prior to entering the microfilter system.

2.8 FEED AND REVERSE FILTRATION PUMPS

- A. Each microfilter system shall be supplied with on-skid centrifugal pumps to feed the raw water to the membranes and for reverse filtration (backwash) of the membranes.
- B. The raw water feed pump shall be used to deliver CIP solution to the membrane modules. The raw water feed pump shall provide the specified rate of filtrate flow with a minimum residual pressure of 5 PSIG at the filtrate outlet. The feed pump is driven by the variable frequency drive (VFD) so that the filtrate flow rate is maintained over varying levels of flow resistance due to loading of the membranes. The VFD is mounted on the MF skid.
- C. The reverse filtration pump shall deliver filtrate from the RF tank to the membrane modules in the reverse direction to backwash the membranes. The RF pump assembly shall be driven by the variable frequency drive (VFD) so that the proper flow to backwash the membranes can be maintained, even if the number of modules changes. The VFD shall be mounted on the MF skid
- D. The raw water and reverse filtration pumps shall each have motor nameplates listing information per NEMA MGI-10.38 or MGI-20.60, as applicable.
- E. The raw water and reverse filtration pumps shall have the following features:

<u>Feature</u>	<u>Feed Pump</u>	<u>Reverse Filtration Pump</u>
Type	316L Stainless Steel SSH	316L Stainless Steel SSH
Manufacturer	Goulds	Goulds
Model	6SH2N52D2	6SH2N52D2
Capacity	385 gpm	625 gpm
TDH	105 ft	70 ft
Mechanical Seal:	(John Crane Type 21) - Carbon/Silicon Carbide/EPR	John Crane Type 21- Carbon/Silicon Carbide/EPR
Motor		
Horsepower	20	20
Type	3-phase TEFC, 2-pole	3-phase TEFC, 2-pole

Efficiency	Standard	Standard
Speed, RPM	3500	3500
Service factor	1.15 at 40 ⁰ C	1.15 at 40 ⁰ C
Time rating	Continuous at 40 ⁰ C	Continuous at 40 ⁰ C
Motor nameplate	Stainless steel	Stainless steel
VFD		
Manufacturer	Danfoss	Danfoss
Horsepower	20	20
Enclosure	NEMA 4X	NEMA 4X

2.9 FEED/CIP TANK

- A. The microfilter system shall include a feed tank as a buffer to the raw water supply. A skid-mounted raw water pump shall convey raw water from the feed tank through the microfilter system.
- B. The feed tank shall also serve the purpose of a recycle tank for chemical clean in place (CIP) solutions. The feed tank shall be constructed of HDPE and be compatible with CIP/water treatment chemicals such as sodium hypochlorite, organic acids, potassium permanganate, chlorine dioxide, and sodium hydroxide. Tank capacity shall be 390 gallons.
- C. The tank shall be equipped with a removable or hinged cover so that CIP chemicals can be fed manually if the automated chemical feed system fails.
- D. The feed tank shall be equipped with level instrumentation and a modulating control valve sized to operate in the range of 5-30 PSIG upstream pressure to control tank level.

2.10 REVERSE FILTRATION (RF) TANK

- A. Each microfilter skid shall be equipped with a fully enclosed reverse filtration (RF) tank to store filtrate to be used for backwash of the membranes. Tank capacity shall be 550 gallons.
- B. The RF tank shall be equipped with level instrumentation and an on-off valve to prevent overflow in normal operation.
- C. The RF Tank shall be fully enclosed to prevent contamination. It shall be vented through a filter assembly with removable cartridges rated at 10 microns absolute.
 - 1. Vent filter shall be Solberg F-231P-200 Polyester Element or equal
 - 2. The vent filter cartridges must be checked and replaced on a regular maintenance schedule to prevent pressurization and potential damage to the tank.

D. The RF tank shall be constructed of HDPE and be compatible with CIP/water treatment chemicals including sodium hypochlorite, organic acids, potassium permanganate, chlorine dioxide, and sodium hydroxide.

2.11 CHEMICAL, HOT WATER, NEUTRALIZATION (CHN) SKID

A. Provide a CHN system to perform the following functions:

1. Warm water for CIP (Clean-In-Place) operations.
2. Provide EFM (Enhanced Flux Maintenance) capability.
3. Provide capability for automatic injection of CIP chemical.

B. Equipment for the CHN skid shall be as follows:

1. Tank shall be vertical round style 1100 gallon, HDPE tank manufactured by Snyder or equal.
2. Tank heater shall be Watlow 12kW immersion or equal. Heating element shall be copper.
3. Warm water transfer pump shall be Goulds NPE. Pump shall be centrifugal style and produce a maximum of 50 gpm.
 - a. Motor shall be 1 HP, 3-phase TEFC, 2-pole 3500 rpm as manufactured by Baldor. Motor shall have continuous time rating at 40C and 1.4 service factor at 40C.
 - b. Seal shall be John Crane Type 21 – Carbon/Silicon Carbide/EPR
4. Solenoid Valves shall be 4-way, 24 volts as manufactured by MAC.
5. Flow switch shall be Harwill paddle style with socket weld PVC.
6. Chemical transfer pumps shall be Wilden diaphragm, air operated. Pumps shall produce 0 – 3 gpm and 100 ft. of head with an air consumption of 5 SCFM max.
7. Actuated valves shall be Spears SPL21101J101-010 or equal. Actuated valves shall be 150# ball with pneumatic actuation and constructed of PVC with EPDM O-ring, and PTFE seat.
8. Manual Valves
 - a. Ball valves shall be Spears 3629 socket weld with PVC body and EPDM gaskets.
 - b. Gate valve shall be Spears 2022-010 socket weld with PVC body and EPDM O-ring.
 - c. Check valve shall be Spears 4529-010 ball valve with PVC body and EPDM gaskets.

9. Level Transmitter shall be Rosemount 2088 0-30 PSI with LCD display. Wetted parts shall be 316L SST.
10. Temperature transmitter shall be Rosemount RTD with 316 SS thermowell.

2.12 CIP TRANSFER/INJECTION

- A. Provide automatic transfer of the CIP chemicals into the Recirculation/Feed Tank to eliminate manual addition by the operator. The CIP transfer system includes three additional chemical pumps (mounted on plates) that may be mounted directly on chemical drums or totes, along with the associated solenoid valves, injectors/check valves, foot valves, and programming.
 1. Chemical Transfer pumps shall be Diaphragm style and air operated.
 - a. Pumps shall produce 0-3 gpm flow and 100 ft. head consuming a maximum 5 SCFM air.
 - b. Foot valve shall be Spears ball check 4532-005, PVC, EPDM.
 - c. Injection valve shall be LMI Chem Injector/check valve #38026.
 - d. Approved manufacturer shall be Wilden.

2.13 AIR COMPRESSOR SYSTEM

- A. The microfilter system manufacturer shall determine the compressor and receiver tank capacity required to meet the air requirements of the microfilter systems. The microfilter system manufacturer shall furnish the air compressor system as specified in attached Section 11447 which shall consist of rotary screw compressors, receiver tanks, associated filters, gauges, relief valves, drains, and appurtenances.

2.14 INSTRUMENT AIR SYSTEM

- A. Instrument Air Tubing. Instrument air tubing shall be used to deliver instrument air to the valve actuators and automatic backwashing strainer included on the system. Instrument air tubing shall be 0.25-inch diameter polyethylene. Reusable compression fittings shall be used in the instrument air system.
- B. Instrument air for all purposes enters the system through a common air inlet line. Pressure adjustment shall be provided using adjustable pressure regulating valves manufactured by Festo. The main air intake line shall have a manual lockout valve to allow lockout of air to the system for valve maintenance.

2.15 INSTRUMENTATION

- A. The MF unit shall include at a minimum the following instruments to monitor and report to the control system:

1. Feed tank level
2. Reverse filtration tank level
3. Pre-filter inlet pressure
4. Pre-filter outlet/module feed pressure
5. Filtrate outlet pressure
6. Water temperature near the module
7. Filtrate flow rate exiting the membrane modules
8. Throttling valve position
9. Pressure switch for low-air pressure

B. All analog instrumentation shall use 24VDC, 4-20 mA output. An alarm will sound if the system detects a transmitter failure.

C. Local display of the following shall be included, either as integrated into the transmitter, or as individual indicators for the following:

1. Feed tank level
2. Reverse filtration tank level
3. Pre-filter inlet pressure
4. Pre-filter outlet/module feed pressure
5. Filtrate outlet pressure
6. Filtrate flow rate
7. Instrument air pressure for valve actuation
8. Instrument air pressure for module regeneration
9. Module regeneration air flow rate
10. Turbidimeters, Hach 1720E

D. LEVEL TRANSMITTERS

1. Tank level transmitters shall provide accurate indication of tank level using a pressure measurement of the head in the tank. Wetted components shall be 316L stainless steel. Electronics shall be FM approved and Local LCD display provided.
2. Calibration shall be performed with the use of a Hart Communicator.
3. Level transmitter shall be Rosemount Pressure Indicating Transmitter – 0-30 PSI. Model 2088.

E. PRESSURE TRANSMITTERS

1. Pressure transmitters shall be FM approved, with 316L stainless steel wetted components.
2. Calibration shall be performed with the use of a Hart Communicator.
3. Level transmitter shall be Rosemount Pressure Indicating Transmitter – 0-150 PSI. Model 2088.

F. FILTRATE/BACKWASH FLOW TRANSMITTERS

1. Each microfilter skid shall have a single flow transmitter to measure both filtrate and backwash flow.
2. Transmitter
 - a. Manufacturer: Rosemount
 - b. Model: 8711 Flow Tube w/ 8732 Transmitter
 - c. Magnetic type
 - d. PTFE lined wetted components
 - e. Electrodes: Two 316L SS, one ground
 - f. Electronics shall be FM approved
 - g. 12-42V DC Power
3. Flow Tube
 - a. 6" Wafer Type
 - b. Liner: Teflon
 - c. Integral mount to 8732 Transmitter
4. Enclosure: NEMA 4X CSA Type 4X, Integral Mount

G. TEMPERATURE TRANSMITTERS

1. Each microfilter skid shall have a temperature transmitter to protect the membranes from high temperature (maximum temperature entering membrane =104 deg F), and to monitor CIP/EFM temperature to assure proper cleaning.
2. Temperature transmitter shall be RTD type with thermowell constructed of 316 SS.
3. Approved supplier shall be Rosemount (Model 0068 w/ 148 Transmitter)

H. PRESSURE GAUGES

1. Bourdon tube type with a liquid filled 2.5-inch diameter dial display.
2. Tube, socket, and case materials shall be 316 SS.
3. Readout in both PSI and kPa.
4. Approved supplier shall be Ashcroft

I. PRESSURE SWITCHES

1. Each microfilter skid shall have a pressure switch to verify adequate air pressure to actuate control valves and provide membrane air scrub.
2. Pressure switches shall be diaphragm type with dual action control in a NEMA 4 housing. Stainless steel shall be used for contact with the process air.
3. Approved supplier shall be Barksdale (Model CD2H-A150SS).

J. TURBIDIMETERS

1. Provide turbidimeters to measure and report the raw water and filtrate turbidity (in NTU) for each MF system. Mount turbidimeters on filtrate ports on each skid. The turbidimeters provide an output signal to the MF system PLC.

2. Hach 1720E:

Range	0.001 – 100 NTU
Accuracy	0 – 10 NTU +/- 2% of reading or 0.015 NTU
	10 – 40 NTU +/- 5% of reading
	40 – 100 NTU +/- 10% of reading
Sample Flow	200 – 750 ml/min
	Built-in Bubble Removal Included
Controller	Hach SC-100
Power	100 – 230Vac 50/60 Hz Auto Selectable
Controller Enclosure	Nema 4X
Output	4-20 mA

K. CHLORINE ANALYZERS

1. Provide chlorine analyzers to monitor free or total residual chlorine level using a colorimetric DPD chemistry technique. A sample line is connected to the analyzer, and an analysis is run every 2-1/2 minutes. Chlorine analyzers shall be used to control pre-treatment processes (such as NaOCl

addition for Fe or Mn removal), and for controlling the chlorine residual in the filtrate water. Chlorine analyzers shall be:

Manufacturer	Hach
Model	CL17
Range	0-5 ppm Free Chlorine or Total Residual
Sample Flow	200 mL/min

2.16 VALVES

Valves in contact with raw water or filtrate water shall contain wetted components of stainless steel, PVC, or food grade elastomers.

A. AUTOMATED VALVES

1. Automated valves used for throttling flow control, or on/off valves that cycle regularly shall be butterfly type and incorporate a pneumatic actuator controlled by a 4-way solenoid valve. Butterfly valves shall be lug-style for capture between ANSI B16.5 style flanges. Automated valves and their actuator/positioner shall be certified by the manufacturer to be acceptable for use up to 1,000,000 cycles in water service, using clean, dry, instrument air as the driving force.
2. Pneumatic actuators shall be double rack and pinion type. Actuators shall operate at a drive air pressure of 90 PSIG or greater.
3. Air to valve actuators must be controlled by 4-way electrical solenoid valves that receive electrical signals from the control system. Solenoid valves shall be block mounted. Normally automated valves shall be capable of manual actuation so that the system can be controlled if the main system controller fails. Each automated valve without a spring return actuator shall include two (2) variable port valves that can be set to choke airflow to the actuators, allowing adjustment of opening and closing valve speed.
4. Tubing to deliver air to actuators shall be 0.25-inch polyethylene.
5. Level Control valve shall be 6-inch Tyco/Keystone 222LT Lug-Style Butterfly. Actuator shall be Keystone/Morin 79U Spring Return Pneumatic – Rack and Pinion. Positioner shall be manufactured by SMC.
6. Actuated valves shall be Tyco/Keystone 222LT Lug-Style Butterfly. Spring return actuator shall be Keystone/Morin 79U Spring Return Pneumatic – Rack and Pinion. Dual Acting actuator shall be Keystone/Morin 79U Dual Acting Pneumatic – Rack and Pinion.
7. Solenoid valves shall be manufactured by Festo.

B. MANUAL VALVES

1. Manual valves for on/off service shall be ball or butterfly type. For throttling service, manual valves shall lock in place to prevent position changes without manual intervention.
2. Water and Low Pressure Air (< 50 psi)
 - a. Butterfly valves shall be Tyco/Keystone 222LT Lug-Style Butterfly. Body shall be cast iron. Disc and stem shall be 316 SS. Seat shall be EPDM Food Grade.
 - b. Ball valves greater than or equal to 1-inch shall be Spears 3629 Socket Weld.
 - c. Ball valves less than 1-inch shall be Spears 1529 Threaded.
 - d. Globe valves shall be Trueline N-651 200 PSI Stainless Threaded (316 SS)
 - e. Air check valves shall be Apollo-Conbraco Seris 62 Ball Check , SS Body.
3. High Pressure Air valves shall be Numatics VL40N12YA w/ Muffler, Lockout Capable.
4. Control Air pressure regulators shall be Monnier Model FR22 Coalescing Filter/Regulator w/gauge.
5. Process Air pressure regulators shall be Wilkerson Model R41 w/gauge.

2.17 CONTROL SYSTEM

A. The control system shall be capable of operating the system automatically with minimum operator intervention. In automatic mode, the system shall monitor the instrument readings and adjust the system's operation in accordance with the pre-programmed logic. The control system shall alarm operators of abnormal conditions, and provide an interface so that an operator can manually operate the system.

Programmable Logic Controllers: – Each microfilter system shall have an Allen Bradley ControlLogix 5000 series PLC to control pumps, valves, etc. For a single skid, control is by the Flexlogix™ PLC processor. For multiple skid control, the ControlLogix™ PLC processor is used in the master control panel with Flex™ I/O blocks in each additional panel.

B. CONTROL ENCLOSURE

1. The microfilter system shall have a main control panel mounted on the support skid. The control panel shall be NEMA 4 rating and be designed and constructed per the National Electrical Code (NFPA 70) and NFPA

79. The main control enclosure shall be constructed of carbon steel and shall be commercial-grit blasted to SSPC-SP10, primed with one coat of aromatic urethane zinc-rich primer (2.5-3.5 mils DFT) followed by 4 - 5 mil DFT finish coat of Tnemec Endurashield, Series 73 (11sf safety blue), applied in two passes with partial drying between passes (equals one high-build coat). Total coating system (primer plus finish) is 7.0 mil DFT minimum.
2. Approved supplier shall be Hoffman.

C. OPERATOR INTERFACE TERMINAL (OIT)

1. The main control enclosure shall incorporate a graphical operator interface with a diagonal display length of 7 inches. The operator interface shall be programmed to display the system in line drawing form to allow clear visual confirmation of the system status. This interface shall allow the system to be started and stopped in automatic mode, display process variables and alarms, allow the user to adjust system set points, silence/acknowledge alarms, manually initiate automated processes (i.e. filtration, regeneration, integrity test, etc.), prompt the user in a step by step fashion during manual procedures (i.e. CIP procedures), and allow manual operation of the system by allowing the user to position individual valves and control pumps.
2. OIT shall be Allen Bradley PanelView Plus™ 700 – 12 to 15-inch Diagonal model.
3. Software shall be RSView HMI programming software.
4. In addition to the graphical OIT, the enclosure door shall contain the following devices, each containing a UL mark:
 - a. Pilot light to indicate a general alarm condition
 - b. Pilot light to indicate that instrumentation voltage is present
 - c. Lighted QUICK stop pushbutton (lit when the Q-stop is engaged)
 - d. Fused disconnect door latch

D. PROGRAMMABLE LOGIC CONTROLLER

1. The system's main controller shall be a commercially available programmable logic controller (PLC) mounted within the enclosure. This PLC shall have sufficient I/O to automatically operate the control valves, operate the system's pumps, and receive input from the instruments included with the system. A block of terminals shall be provided within the control panel which is specifically designated to receive input from customer's instruments. The PLC will accept signals from customer's upstream or downstream equipment so that the system can be

automatically stopped, started, or production rate changed based on the availability of feed water or filtrate storage space.

2. Wiring to/from PLC input/output modules shall run through a properly sized fuse to protect the instrument or PLC module.
3. The control system shall include the following hardware.
 - a. PLC shall be Allen-Bradley ControLogix 5000
 - b. Local I/O discrete modules shall be Allen-Bradley.
 - c. Local I/O analog modules shall be Allen-Bradley.
 - d. Power Supply shall be manufactured by Allen-Bradley.
 - e. Terminal Blocks shall be manufactured by Allen-Bradley.
 - f. Control enclosures shall be Hoffman or equal.
 - g. Control panel indicator lights and switches shall be Allen-Bradley.
 - h. HMI Interface shall be PanelView by Allen-Bradley.
 - i. Networking hardware shall be Phoenix Contact or equal.
4. CHN System

The CHN (chemical, hot water, neutralization) system is designed to deliver hot and cold water, and various chemicals to a filtration skid for the Enhanced Flux Maintenance (EFM) and Clean-In-Place (CIP) processes. It can also be used to provide solutions to neutralize discarded acid and caustic solutions that were used during a Clean In Place process.

- a. CHN Hardware - The CHN includes a local panel with local I/O that is connected to the filtration skid via Ethernet.
- b. Local I/O: The CHN uses Allen-Bradley® Flex™ I/O series I/O products.
- c. CHN Networking – the CHN is connected to the filtration skids via Ethernet.

5. Multiple Microfilter Skid Control:

For multiple skid systems, a master PLC in a wall-mounted panel with distributed I/O shall control all filtration skid processes and devices and the CHN skid processes and devices. The master PLC will be an Allen-Bradley® ControLogix™ programmable logic controller. Each filtration skid will contain a Festo Solenoid and I/O manifold. Communications between the master PLC and HMI shall be via Ethernet. Communications between the master PLC and the filtration skids shall be via Ethernet. The standard master control enclosure must be mounted in close proximity to, and in full view of the filtration skids and contain a PanelView™ HMI.

E. NETWORK ACCESS

1. The microfilter system shall include an Ethernet connection port for connecting the system to a Local Area Network and an existing SCADA system.

F. SCADA SYSTEM

1. Provide a PC-based SCADA system that allows remote access to PLC, capability for remote troubleshooting and operation of the system, and alarm dial-out.
2. Equipment Specifications:
 - a. Allen-Bradley Panelview HMI
 - b. Software – Rockwell RSView®, Microsoft® Excel, RSView® Messenger™, pcAnywhere™

G. ALARMS

1. Alarm conditions shall be displayed and acknowledged at the main OIT. An alarm condition shall also cause the alarm pilot light to be lit, and an audible horn mounted on the control panel shall sound. Controls shall be included to allow the operator to silence the horn, but the alarm will continue to be visually displayed until the alarm is corrected/acknowledged.
2. The following alarm conditions shall be included as a minimum:
 - a. Q-stop
 - b. Feed Pump Fault
 - c. RF Pump Fault
 - d. Lack of feed fluid/filtrate storage
 - e. Low Air Pressure
 - f. Integrity Test Failure
 - g. Low/high RF tank level
 - h. High/Low feed tank level
 - i. CIP required (high TMP)
 - j. High turbidity (optional)
 - k. High/low water temperature
 - l. Level, pressure, flow, temperature transmitter failure

H. QUICK STOP

When the Q-stop pushbutton (located on the control panel door) is pressed, all pumps on the microfilter skid shall stop, and the system's inlet, outlet, and drain valves shall close. The system will not be able to operate again until the operator disengages the Q-stop button.

I. CONTROL ENCLOSURE WIRING

1. The main control panel shall be completely wired at the factory. Control enclosures shall be designed and constructed in accordance with UL 508A, and only by manufacturer's capable of listing equipment to UL 508A. All components within the control enclosure shall contain a UL mark and have termination points that are finger safe.
2. Power brought to the cabinet in the specified voltage only needs to be terminated at a fused disconnect switch that is interlocked to the enclosure door. A power supply shall be provided to convert the base voltage of the system to alternate voltages that may be required by components on the skid (120V 1 phase, 24VDC, etc.).
3. A surge suppressor shall be included in the main enclosure to protect the power supply, the PLC and I/O modules, and the skid mounted valves and instruments from power surges.
4. Wiring within the panel shall be routed through plastic wire ways for neatness and organization. Where feasible, conductors for high (120 VAC and above) and low (24VDC) voltage shall remain separated. Copper wire shall be used and sized for its load per NEC/NFPA79 requirements. All wires will terminate through a ferrule type connector and terminate on finger safe, screw clamping terminal blocks.

2.18 ELECTRICAL WIRING

- A. Microfilter system shall be delivered completely pre-wired from the main control enclosure to solenoid valves and instruments. Wiring shall be copper, and sized for its load per NEC/NFPA79 requirements. All wires will terminate on screw clamping terminal blocks.
- B. Wires from the main control enclosure shall be enclosed in conduit made of PVC or flex-tite style PVC conduit that is completely sealed from moisture. Where practical, low voltage control conductors (24VDC) shall be separated from those carrying high voltage power (120VAC and above).

2.19 PIPE AND FITTINGS

- A. The microfilter system plumbing shall incorporate stainless steel, HDPE, or PVC pipe and fittings.

- B. Stainless steel pipe shall conform to ANSI B36.19 and be constructed of schedule 10s austenitic stainless steel to ANSI A312 type 304, 304L, 316, or 316L. Only welders qualified to section IX of the ASME/ANSI boiler and pressure vessel code shall perform welding of SS pipes.
- C. PVC pipe shall be NSF approved Type 1 Grade 1 gray with compounds conforming to ASTM D-1784. Pipe and fitting wall thickness shall be schedule 40 or schedule 80. Socket welded fittings shall be used whenever possible, using solvent bonding techniques.
- D. Flanges shall use bolting patterns per ASME/ANSI B16.5.

2.20 FRAME ASSEMBLIES

- A. The microfilter system and modules shall be mounted on a steel framework fabricated primarily from square tubing. Angles, plate, round pipe, or other structural shapes may be welded to the tubing for use as legs or mounting brackets for pumps, instruments, and other components. Frame materials shall be seal welded together to prevent moisture from entering the welded joint or the interior of closed elements such as tubing or pipe. Personnel performing welding shall be qualified to AWS 1.1.
- B. Frame material shall be carbon steel. It shall be commercial grit blasted to SSPC-SP10 and primed with one coat of Tnemec 90-97 Tnemec-zinc, 2.5-3.5mil DFT. 4 - 5 mil DFT finish coat of Tnemec Endurashield, series 73 (11sf safety blue) shall be applied in two passes with partial drying between passes (equals one high-build coat).
- C. The frame shall have legs with steel base plates for anchoring to a foundation using anchor bolts and nuts.

2.21 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. Provide a UPS (Uninterruptible Power Supply) for the master PLC and each MF skid. The UPS shall provide 30 minutes of power to the master PLC during a short-term power outage, allowing the system to restart automatically.
 - 1. UPS shall be compatible with electrical power supply from an emergency generator without shutdown of the microfilter system.
 - 2. UPS shall be 1kVa, 120V manufactured by Eaton Powerware.

2.22 SPARE PARTS AND EQUIPMENT

- A. Provide the following spare parts and equipment:
 - 1. One spare chemical metering pump
 - 2. One spare feed pump
 - 3. One spare reverse filtration pump

PART 3 - EXECUTION

3.1 GENERAL

- A. The manufacturer shall provide packaging to prevent damage during transit and handling.
- B. Storage and start-up shall conform to the manufacturer's recommendations and drawings, and these specifications. Notify Engineer of any discrepancies immediately.
- C. To accommodate shipping, unloading, and installation, the microfiltration system shall be provided in one or more pieces to be installed at the site. If it is necessary to separate the system into two or more assemblies, such as when an off-skid module rack is provided, all the necessary interconnecting piping, tubing, wiring, etc. shall be provided by the manufacturer for the system to operate as a unit. The contractor shall install the interconnect piping, wiring, tubing, etc.

3.2 FACTORY TESTS

All certification of factory tests and materials shall be submitted and approved by the Engineer before shipping equipment. Any equipment shipped prior to approval of all required data and materials shall be returned to the manufacturer at his expense for modification or replacement as required.

3.3 TRAINING

- A. Provide the service of a factory certified service technician for three (3) full days onsite to inspect the installation, assist in start-up, and initial operation of the equipment; and three (3) full days onsite to instruct plant personnel in the operation and maintenance of the equipment. A minimum of 6 full days on site, including travel expenses.
- B. Training of plant staff shall meet the requirements of attached Section 01640.
- C. Factory certified service technician shall provide a field report certifying that the equipment is properly installed, fully operational and ready for use. Copies of the report shall be provided in accordance with attached Section 01650.
- D. The initial operation of all components shall be certified as specified in attached Section 11000.

3.4 TESTING

- A. After completion of the installation and manufacturer's certification, equipment shall be field tested to demonstrate compliance with the requirements specified.

Submit a testing plan prior to field testing. Testing of equipment shall be conducted in accordance with the requirements of attached Section 16030.

- B. Microfilter systems shall operate continuously for a minimum of thirty days prior to acceptance by the Owner.
- C. Owner shall supply chemicals for testing and start-up of Clean-in-Place (CIP) system, Enhanced Flux Maintenance (EFM), instruments or other purposes.

END OF SECTION

The bidder shall complete and return Exhibit "B". Failure to do so may result in the disqualification of your bid.

EXHIBIT "B"

**Purchase of Microfiltration System for the Bealeton Water Treatment Facility
Contract No. 14-E-02-0203**

BID PROPOSAL FORM

In the spaces provided below, the bidder shall state the total delivered bid price for the equipment listed that meets the specifications contained in Exhibit "A" – Bid Specifications. Bid price shall include all equipment, delivery, installation inspection and start-up services, warranty, IOM manuals, spare parts list, and training.

<u>Description</u>	<u>Purchase Price</u>
Microfiltration System In accordance with the bid specifications as provided for in Exhibit "A"	\$ _____
Bidder shall state make and model: _____ _____ _____	

Delivery Terms: _____ calendar days from receipt of order.

Firm Pricing: Vendor agrees to hold pricing firm for a period of one hundred eighty (180) days from date of bid opening.

Company Name: _____

Authorized Signature: _____

**THE FAUQUIER COUNTY WATER AND SANITATION AUTHORITY RESERVES THE
RIGHT TO REJECT ANY OR ALL BIDS OR TO WAIVE IRREGULARITIES THEREIN.**

APPENDIX A

Additional Specifications

SECTION 01300
TECHNICAL SUBMITTALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes

1. Submittal Procedures
2. Shop Drawings
3. Samples
4. Product Data

1.2 SUBMITTAL PROCEDURES

A. Approval Requests: As the Work progresses and in the sequence indicated by the accepted Progress Schedule, the Contractor shall submit to the Engineer a specific request in writing for each item of information or approval required of him by the Contract. These requests shall be submitted sufficiently in advance of the date upon which the information or approval is actually required by the Contractor to allow for the time the Engineer will take to act upon such submissions or resubmissions. The Contractor shall not have any right to an extension of time due to delays caused by his failure to submit his requests for the required information or the required approval on time.

B. Transmittal: The Contractor shall submit to the Engineer, at the address given in the Agreement, 5 complete copies or an electronic file of each submittal unless otherwise noted. Submittals shall be accompanied by a letter of transmittal containing the following information:

1. Submittal number: Number submittals sequentially.
2. Identification of the Contractor, subcontractor or supplier.
3. Project title, project number and division, and contract number.
4. Specification Section number, Section submittal number and suffix.
5. Drawing sheet, and detail number as appropriate.

6. Contractor's stamp or certification the products have been reviewed and are in accordance with the requirements of the Work and the Contract Documents.
7. Listing of variations from Contract Documents and any limitations which may be detrimental to the Work.

C. Review by Engineer: Drawings or descriptive data will be marked "Approved," "Approved as Noted," "Revise and Resubmit," or "Rejected" and Contractor's copies together with a letter of transmittal will be returned to the Contractor.

D. No Additional Copies Required: When the drawings and data are returned marked "Approved," no additional copies need be furnished.

E. Corrected Copies: When submittals are marked "Approved As Noted", two corrected copies with changes highlighted shall be submitted. If additional, new changes are proposed, they shall be submitted in accordance with Paragraph B of this Article.

F. Resubmittals: When the drawings and data are returned and marked "Revised and Resubmit" or "Rejected," the corrections shall be made as noted thereon and as instructed by the Engineer, and corrected copies shall be resubmitted in accordance with Paragraph B of this Article. When corrected copies are resubmitted, the Contractor shall in writing direct specific attention to all revisions and shall list separately any revisions other than those called for by the Engineer on previous submittals. A marked copy of the original submittal shall also accompany the resubmittal.

1. Resubmittals shall be given an alphabetic suffix to the Section submittal number of the original submittal to indicate which resubmittal it is (i.e.; #a indicates first resubmittal, #b indicates second and so forth).
2. Letter of Resubmittal: Contractor's letter of resubmittal shall list the date of his original submittal letter, the date of the Engineer's letter returning the submittal, and the dates of submission and return of any previous resubmittals.

1.3 NOT USED

- A. Submit within 20 days after the execution of this Contract or as directed by the Engineer for projects assigned under this contract.
- B. Prepare schedules as a horizontal bar chart with separate bar for each major operation or portion of Work identifying first workday of each week.
- C. Provide space to show proposed and actual progress, notations and revisions.

- D. Show complete sequence and direction of construction by activity with beginning and ending dates and stations of each element of construction.
- E. Activities shall include receipt and unloading of pipe, installation of pipe, VDOT crossings, anticipated shutdown of mains, hydrostatic testing and closures at minimum.
- F. Provide subschedules to amplify critical activities.
- G. Show accumulated percentage of completion of each item and total percentage of Work completed as of the 25th day of each month.

1.4 SHOP DRAWINGS

- A. Shop Drawings: The Contractor shall promptly prepare and submit layout, detail, and shop drawings for such parts of the Work as specified.
- B. Schedule: A schedule of shop drawing submittals shall be submitted for the Engineer's review within 20 days after the Notice to Proceed for each Project assigned under this Contract.
- C. Project Information: Each shop drawing shall be dated and shall contain the following: (1) Project Name, (2) Contract Number, (3) Submittal Number, (4) Project Identification, (5) Drawing Title, (6) Reference to Contract Drawing Number and specification section and paragraph, (7) Contractor's certification statement, (8) names of equipment or materials, and (9) the locations at which the equipment or materials are to be installed in the Work. The Engineer may decline to consider any shop drawing that does not contain complete data on the Work and full information on related matters.
- D. Requirements: Shop drawings shall present, where applicable, engineering data and descriptive information in sufficient detail to show the kind, size, arrangement, and operation of component materials and devices; the external connections, anchorages, and supports required; performance characteristics; and dimensions needed for installation and correlation with other materials and equipment.
 1. Numbering and Additional Considerations: Shop drawings shall be numbered consecutively and shall accurately and distinctly present the following:
 - a. All working and erection dimensions
 - b. Arrangement and sectional views

- c. Necessary details, including complete information for making connections between Work under this Contract and work under other contracts
- d. Types of materials and finishes
- e. A list and description of parts

E. Review by Contractor:

- 1. The Contractor shall check and approve all shop drawings before transmitting them to the Engineer to determine that they comply with the requirements of the Contract Documents. Drawings which are not complete or are not in compliance with the Contract Documents shall not be submitted. All shop drawing submittals, regardless of origin, shall be stamped with the approval of the Contractor and identified with the Contractor's name and references to applicable specification paragraphs and Contract Drawings. Each shop drawing submittal shall indicate the intended use of the item in the Work. When catalog pages are submitted, applicable items shall be clearly identified. Non-applicable data shall be stricken from the submittal. The current revision, issue number, and date shall be indicated on all shop drawings and other descriptive data. The Contractor's stamp of approval shall constitute a representation to the Owner and the Engineer that the Contractor accepts full responsibility for determining and verifying all quantities, dimensions, field construction criteria, materials, catalog numbers, and similar data; that he has reviewed or coordinated each submittal with the requirements of the Work and the Contract Documents; and that the submittal fully meets the requirements of the Contract Documents or is specifically marked otherwise.
- 2. Deviations from Contract Requirements: If the shop drawings show deviations from the Contract requirements, the Contractor shall make specific mention thereof as previously specified in this Section. Review of such submittals shall not constitute approval of the deviation. Review of the shop drawings shall constitute review of the subject matter thereof only and not of any structure, arterial, equipment, or apparatus shown or indicated. Such submittals shall, as pertinent to the deviation, indicate essential details of all changes proposed by the Contractor (including modifications to other facilities that may be a result of the deviation) and all required piping and wiring diagrams, all in accordance with Section 01630 Product Options and Substitutions.
- 3. Completeness of Shop Drawings: The Contractor shall accept full responsibility for the completeness of each submittal, and, in the case of a resubmittal, shall verify that all exceptions previously noted by the Engineer have been taken into account. In the event that more than one resubmittal is required because of the Contractor's failure to account for exceptions previously noted, the Contractor shall reimburse the Owner for the Engineer's charges for reviewing the additional resubmittals.

F. Review of Shop Drawings by Engineer: The review of shop drawings will be general and shall not relieve the Contractor of responsibility for the accuracy of such drawings, or for the proper fitting and construction of the Work, or for the furnishing of materials or Work required by the Contract and not indicated on the shop drawings. No Work called for by shop drawings shall be done until the said drawings have been reviewed and approved by the Engineer.

G. Resubmittals:

1. Resubmittals within 30 Days: Resubmittals shall be made within 30 days of the date of the letter returning the material to be modified or corrected, unless within 14 days the Contractor submits an acceptable request for an extension of the stipulated time period, listing the reasons the resubmittal cannot be complete within that time.
2. Additional Resubmittals: Any need for more than one resubmittal or any other delay in obtaining the Engineer's review of submittals will not entitle the Contractor to an extension of time unless a delay of the Work is directly caused by an authorized change in the Work or by the Engineer's failure to return any submittal.

1.5 SAMPLES

A. General: When required, the Contractor shall submit to the Engineer for review typical samples of materials and appliances. The samples shall be properly identified by tags and shall be submitted sufficiently in advance of the time when they are to be incorporated into the Work so that rejections thereof will not cause delay. A letter of transmittal, in triplicate, from the Contractor requesting review must accompany all such samples.

1.6 PRODUCT DATA

A. General: Submit Manufacturer's standard product data when special fabrication is not required.

1. Products proposed for use in the Work shall be clearly designated in order for submittal to be considered for approval.
2. Manufacturer's product data shall provide sufficient information for thorough review.

- a. Attach supplemental information to detail how the product will be installed in the Work.
3. Line through extraneous information.

PART 2 - PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01630
PRODUCT OPTIONS AND SUBSTITUTIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section outlines the policies and procedures for obtaining consideration and acceptance of products other than those specified.

1.2 DESIGN REQUIREMENTS

- A. Intention of Contract Documents: It is the intention of these Contract Documents that the Work be constructed with the specified products. The Contractor shall base the bid price on the products specified. The FCWSA has the right to reject proposed substitutions for any reason.
- B. Equivalent Materials and Equipment
 - 1. Whenever a material, article or method is specified or described by using the name of a proprietary product or the name of a particular manufacturer(s) or vendor(s), followed by the phrase "or equal", the specific item mentioned shall be understood as establishing the type, function, dimension, appearance, and quality desired and is to be the basis upon which bids are to be prepared. Other manufacturer's materials, articles and methods not named will be considered as substitutions provided required information is submitted in the manner set forth herein and provided substitution will not require substantial revisions of the Contract Documents. This applies to specific construction methods when such are required by the Contract Documents.
 - 2. Whenever a material, article, or method is specified or described without the phrase "or equal", no substitutions will be allowed.

1.3 SUBMITTALS

- A. Submittal of Proposed Substitutions: Bids shall be based on materials, articles and methods named and specified in the Contract Documents. If the bidder proposes to use substitutions for named and specified materials, articles and methods followed by the phrase "or equal" within the Contract Documents during the construction process, he shall submit a list of proposed substitutions on the Form For Substitutions For Specific Items with his BID. This form is provided in the Bid Form and Attachment portion of the Bid Documents for this purpose. Request for substitutions received after bids are open will not be considered except as stated herein. The Contractor shall submit a separate request for each product, supported

with complete data, drawings, and samples as appropriate. Three copies of the following data, including but not limited to, the following information shall be submitted in order for substitutions to be considered.

B. Contractor to Submit Requests for Substitutions: Requests for review of a substitution or equivalent will not be accepted from anyone except the Contractor. Moreover, such requests will not be reviewed until after the contract award. Complete data for substitutions must be submitted not later than twenty (20) days after date of Notice to Proceed.

1. Comparisons of the proposed substitution with the product specified.
2. Changes required in other elements of the work because of the substitutions.
3. Effects on the Construction Schedule.
4. Cost data comparing the proposed substitution with the product specified and the amount of credit that the Contractor proposes to issue to the authority if the proposed substitution is accepted.

C. Substitutions After Bid Opening

1. Requests for substitutions submitted after Bid Opening will not be considered unless evidence is submitted to the Engineer that the following circumstances exist:
 2. Unavailability of specified product.
 - a. The specified material is unavailable for reasons stated elsewhere in these Specifications.
 - b. Complete data as set forth hereinbefore to permit complete analysis of the proposed substitution are submitted with the request.

D. Rejection of Proposed Substitution: Substitutions will not be considered at any time if:

1. They are indicated or implied on Contractor's drawings or project data submittals without formal request submitted in accordance with this Section.
2. Acceptance will require substantial revision of Contract Documents.
3. Acceptance will create problems in stocking of repair parts and in future maintenance by the Owner.

E. Approval of Substitution: The Engineer's decision regarding evaluation of substitutions shall be final and binding. Request for time extensions and additional costs based on submission acceptance or rejection of substitutions will not be allowed. All approved substitutions will be incorporated into the Contract by Change Order.

1.4 QUALITY ASSURANCE

A. Contractor Certification: By the submittal of a substitution request, the Contractor shall represent that:

1. An investigation of the proposed substitute product has determined that it is equal to or superior in all respects to the product specified;
2. The same warranties or bonds will be provided for the substitutions as for the specified products;
3. Coordination will be provided for the installation of an accepted substitution into the Work and other changes as required to make the Work complete in all respects;
4. All claims for additional costs due to the substitution which may subsequently become apparent shall be waived.

B. Contractor Responsible for Performance: Neither the acceptance by the Engineer of alternate material or equipment as being equivalent to that specified nor the furnishing of the material or equipment specified shall in any way relieve the Contractor of responsibility for failure of the material or equipment due to faulty design, material, or workmanship, to perform the functions required by the Contract Documents.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 01640

TRAINING

PART 1 - GENERAL

1.1 SCOPE

- A. Training of the Owner's operations personnel on the proper care, maintenance and operation of the equipment. Also included are the preparation of lesson plans and training aids and the required qualifications for instructors.
- B. The Requirements. Provide the services of qualified factory trained representatives of the equipment manufacturers for all equipment furnished under this Contract, who shall provide operations and maintenance training.
- C. Training shall be completed before Reliability Demonstration Testing and after field testing & start-up. Training shall not be conducted earlier than sixty (60) days prior to Substantial Completion. Training shall not be conducted on the same day as field testing and start-up services as specified in Section 01650, Field Testing and Startup.
- D. Operation and Maintenance Manuals as specified in Section 01730, O&M Manuals, are required to be approved prior to beginning training.

1.2 SUBMITTALS

- A. The Contractor shall submit the following items as and when specified in this Section:
 - 1. Lesson Plans
 - 2. Instructor Qualifications
 - 3. Training Aids

1.3 TRAINING

- A. The training shall consist of field instruction.
 - 1. Field instruction is the Owner's preference and is to be "hands on type training" conducted at the equipment installations. Field training shall identify the location and proper use and function of any valves, pushbuttons, control panels, switches, and other similar equipment required for operation. Field training shall also identify

the location and proper use and function of any maintenance equipment such as grease fittings, oilers, isolation valves, safety lockout switches, and other similar equipment.

2. Instruction shall consist of equipment component theory of operation, start-up and shutdown, safety, troubleshooting and routine maintenance training best presented in a classroom environment and as approved by the Owner.

B. All field training shall take place at the project site.

C. Training sessions shall be conducted between the hours of 8:00 a.m. and 4:00 p.m.

D. For each piece of equipment, training sessions shall be provided.

E. Schedule training sessions with the Owner and the Engineer, providing a minimum of fourteen (14) days prior notice of training, subject to the approval of the Engineer and the Owner.

F. Videotaping

1. The Owner reserves the right to videotape all manufacturers' training.
2. The manufacturer may offer prerecorded videotape(s) covering the equipment supplied. If prerecorded videotape(s) are provided, the Owner shall have the right to permanent ownership and use of at least two complete copies.

G. Lesson Plans: Submit lesson plans that include specific information about each item of equipment or equipment system, including controls.

1. Submit lesson plans for approval by the Engineer no less than sixty (60) days prior to the date of the proposed training.
2. The lesson plans shall indicate when training aids are used or referred to during the course of instruction.
3. Outline of lesson plan
 - a. Equipment Description
 - 1) Purpose and function of equipment and auxiliary equipment and systems.
 - 2) Physical arrangement of equipment components and electrical supply.
 - 3) General function of controls, including automatic and manual operation, interlocks, and shutdowns.
 - b. Equipment Operation
 - 1) Operating requirement for equipment to perform satisfactorily.
 - 2) Typical operating characteristics.
 - 3) Start-up and shutdown procedures.

- 4) Use of controls
- d. Equipment Monitoring
 - 1) Recommended routine instrument readings and operational checking.
 - 2) Early warning signs of developing operational or equipment problems.
 - 3) Description of the facilities Supervisory Control and Data Acquisition (SCADA) System
- e. Equipment operational troubleshooting procedures.
- f. Safety and Housekeeping
 - 1) Safety features of the equipment.
 - 2) Safe work practices.
 - 3) Housekeeping practices.
- g. Description of the use of the equipment manufacturer's Operations and Maintenance Manual (O&M Manual) in regards to operation.
- h. Preventive Maintenance Requirements
 - 1) Maintenance needs for equipment.
 - 2) Identification of procedure to satisfy maintenance need (relate to equipment manufacturer's O&M Manual, which should have detailed descriptions of maintenance procedures).
 - 3) Outline or summarize procedures.
 - 4) Recommended schedule for performing preventive maintenance.
 - 5) Provide preventive maintenance record forms (if available).
- i. Maintenance Inspection Program
 - 1) Parts, components, and areas of equipment to inspect for routine preventive maintenance.
 - 2) Recommended frequency of inspection.
 - 3) Inspection procedures.
 - 4) Problem Identification.
- j. Maintenance Troubleshooting
 - 1) Sections in O&M Manual detailing troubleshooting procedures.
 - 2) Summarize troubleshooting procedures.
 - 3) Testing equipment used in troubleshooting.
 - a) Demonstration use of specialized testing equipment if supplied with equipment.
 - b) Other testing equipment.
 - 4) Tests used to verify troubleshooting findings.

k. Disassembly and Assembly

- 1) Summarize disassembly and assembly procedures.
- 2) O&M Manual coverage of subject.
- 3) Testing to verify success of corrective maintenance.

l. Equipment Calibration

- 1) Calibration needs and tolerances.
- 2) Calibration equipment.
- 3) O&M Manual listing of calibration ranges, tolerances and settings.

H. Training Aids: Training aids shall be provided by the Contractor as required as an integral part of the training program.

1. Training aids shall include text and/or pictorial handouts specific to the equipment supplied.
 - a. Submit a copy of the training aids (text and/or pictorial handouts) for approval by the Engineer no less than sixty (60) days prior to the date of the proposed training.
 - b. Handouts shall be legible and printed on good quality stock.
 - c. Final handouts shall be provided with lesson plans to each trainee at the time of training.
 - d. Sufficient quantity of final (accepted) handouts for each attendee (trainee) shall be provided by the Contractor.
2. Additional training aids specific to the facility/system shall be used for maximum training effectiveness and shall include the following as appropriate:
 - a. Audio visual aids, for example: films, videotapes, slides, overhead transparencies, posters, blueprints, diagrams, and catalog sheets.
 - b. Models and samples, for example: cutaways, spare parts, tools, miniature models, equipment assemblies, and damaged parts.
 - c. Training equipment (laptops, projectors, screens, etc.) shall be provided by the Contractor.
3. The use of additional training aids shall be identified in the lesson plan, and a description of the additional final (accepted) training aids shall be provided by the Contractor.

I. Qualifications

1. Submit documentation showing the qualifications of the proposed training specialists (instructor) for approval by the Engineer no less than sixty (60) days prior to the date of the proposed training. The documentation shall include the following:
 - a. Experience of the training specialists in operation and maintenance of the equipment;
 - b. A Statement of Instructor Qualifications.

- c. References for previous training on the equipment, including project names, contact names, and phone numbers.
- 2. The training specialist must be knowledgeable of the equipment's application specific to this project.
- 3. Only those training specialists whose qualifications have been approved by the Owner shall conduct training.

J. Coordinate training services with the Owner, the Engineer, and Manufacturer.

K. Deliver all training materials to the Owner at least fourteen (14) days prior to scheduled training.

L. The Contractor shall coordinate and verify to ensure prior to the scheduled training times:

- 1. That all associated construction required to operate the equipment in all normal and anticipated operating modes is complete and that the equipment is ready to be used for training purposes.
- 2. That the equipment area is well lit and unobstructed so that all training class attendees may access, view and hear the training.
- 3. That the equipment area is free of construction activities that could present a hazard to training class participants.

M. During the training, Owner reserves the right to cancel unsatisfactory training at any time. Contractor will be required to reschedule make-up training (at no additional cost to the Owner), at a schedule approved by the Owner.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01650

SYSTEMS START-UP, COMMISSIONING AND TRAINING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section includes demonstration and instructions, start-up and testing procedures for equipment and systems included in the contract documents. Additional start-up, testing, validation, etc., shall also be provided as required by the Contract Documents.

1.2 START-UP AND TESTING OF EQUIPMENT AND SYSTEMS

A. General

- 1. Costs of start-up and testing are considered part of the Contractor's Bid price(s) and no extra compensation will be granted for this phase of Work.
- 2. Submit a start-up and testing plan to the Engineer for approval at least 14 days prior to the initiation of this phase of the work. Include:
 - a. Proposed dates and time periods for starting and testing each system or equipment item.
 - b. Names of manufacturer's representatives which will be present during this phase of the Work and the time periods during which they will be on the Project site.
 - c. Date and time periods proposed for "Demonstration and Instructions" for each system and equipment item.
- 3. Notify the Engineer at least seven days prior to the start-up of each system and equipment item.
- 4. Coordinate start-up and testing of various systems and equipment items.
- 5. Execute equipment and system start-up and testing under supervision of responsible manufacturer's representative and in accordance with manufacturer's instructions.
- 6. Where specified in individual Specification Sections, the manufacturer is required to provide an authorized representative to be present at site to inspect, check, and approve equipment or system installation prior to start-up and testing.
- 7. Specific requirements for electrical system testing are specified in Division 16—ELECTRICAL.

- B. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, control sequence, or other conditions which may cause damage.
- C. Verify that tests, meter readings, and specified electrical characteristics agree with those required by the equipment of system manufacturer.
- D. Verify that instrumentation, control, alarm and annunciation systems are operating properly.
- E. Verify that all valves will open and close without binding.
- F. Check liquid containment structures, piping, and equipment for leaks.
- G. Verify that equipment items are operating without excess vibration.
- H. Verify that all valves will open and close without binding.
- I. Simulate power failure to verify that standby systems function properly and that reactivation of utility power source will not result in damage to or malfunction of equipment and control systems.
- J. See individual Specification Sections for start-up and testing requirements for specific equipment items.
- K. Correct any deficiencies prior to requesting close-out inspection.
- L. Submit a written report certifying that all systems and equipment items are functioning correctly and ready for long-term operation.

1.3 DEMONSTRATION AND INSTRUCTIONS

- A. During start-up and testing operations, demonstrate operation and maintenance of equipment to Owner's personnel in addition to the training specified in Section 01640 - Training.
- B. Where required by individual Specification Sections, require qualified manufacturers' representatives to participate in demonstration and instructions.
- C. Utilize Operation and maintenance manuals as basis for instruction along with other training materials as described in Section 01640-Training. Review contents of manuals with Owner's personnel in detail to explain all aspects of operation and maintenance.
- D. Demonstrate start-up, operation, control, adjustment, troubleshooting, servicing, maintenance, and shutdown of each item of equipment at scheduled times, at equipment location.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION

SECTION 01730

OPERATION AND MAINTENANCE MANUALS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Format and content of manuals.
- B. Schedule of submittals.

1.2 THE REQUIREMENTS

- A. For each equipment item, component, and prepackaged system, prepare and submit an Operation and Maintenance Manual in compliance with the specified requirements.
- B. Approval of the Final Draft Operation and Maintenance Manual is a prerequisite for obtaining payment in excess of ninety (90) percent for the equipment furnished.
- C. Approval of the Final Operation and Maintenance Manual is a prerequisite for obtaining payment in excess of ninety five (95) percent for the equipment furnished.
- D. Approval of the Final Operation and Maintenance Manual is required prior to conducting Training as specified in Section 01640, Training, for the equipment furnished.
- E. All Final Operation and Maintenance Manuals are required to be approved prior to Substantial Completion.

1.3 SUBMITTALS

- A. Preliminary Draft Manual: No later than thirty (30) days after approval of equipment submittal (shop drawing), submit three (3) hard copies of Preliminary Draft Manual for review and approval. Owner will review draft and return one (1) copy with comments. Revise contents of Manual in accordance with Owner's comments as required prior to Final Draft Manual submittal.
- B. Final Draft Manual: No less than thirty (30) days prior to delivery of equipment, submit three (3) hard copies of the Final Draft Manual for review and approval, Engineer will review and return one (1) copy with comments. Revise contents of Manual in accordance with Owner's comments as required prior to Final Manual submittal.

C. Final Manual: Prior to performing training on equipment for which an Operation and Maintenance Manual is required, submit three (3) hard copies and three (3) digital copies of the Final Manual.

1.4 COPYRIGHT

A. Obtain the copyright holder's permission to use all copyrighted material used in the Manuals as necessary.

1.5 FORMAT

A. Hard copy

1. Binding
 - a. Size: 8-112 x 11 inches
 - b. Manuals shall be bound in 3-ring, vinyl covered, loose leaf binders in thickness necessary to accommodate contents, with pockets inside the covers to receive folded oversized sheets.
2. Arrange contents of the manuals according to the appropriate Specification Section.
3. Provide tabbed dividers for each separate product and system with descriptions of product and major component parts of equipment.
4. All printed materials shall be manufacturer's printed data, or typewritten data on 20 pound (minimum) paper. Images and drawings shall be clear, legible, high-quality suitable for photocopying. Drawings 11 x 17 inch and smaller shall be bound in with text; larger drawings shall be folded to the size of text pages and placed in pockets.

B. Digital copy

1. Digital version shall be identical in content to the hard copy version.
2. Provide each digital copy on a separate CD.
3. Provide digital copy in Adobe PDF ® (portable document format) format compatible with the Adobe Reader®.

1.6 GENERAL CONTENTS, EACH MANUAL

A. Content: manuals shall include, but not be limited to:

1. Catalog information.
2. Diagrams.

3. Drawings.
4. Instruction bulletins including installation, operation, maintenance and troubleshooting.
5. Manuals.

B. Cover/Title Page

1. Identify each manual with a typed or printed title, containing the following data:
 - a. "OPERATION AND MAINTENANCE MANUAL",
 - b. Title of project, name of facility, contract number and date
 - c. Subject matter of contents with manufacturers name
 - d. Owner's equipment tag number(s) with equipment name(s).

C. Table of Contents

1. Provide the following:
 - a. Title of project;
 - b. Schedule of products and systems, indexed to content of the volume.
 - c. Manufacturer's Name. Ex.: "XV Company Gate Valve[®] instead of "Gate
 - d. Valve".
2. Attach to the table of contents the names, addresses, and telephone numbers of Engineer, Subcontractors, and Contractor with names of responsible parties.

D. Arrangement: Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

E. Identification: The Operation and Maintenance Manuals shall be specific for the equipment provided for this project. Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Mark by underlining, circling, checking, use of arrows, or crossing out non-applicable information to the equipment for which the manual is supplied. Marking with color highlighter pens is not acceptable.

F. Product Ordering Instructions: For each product or system provide complete instructions for re-ordering specific products or replaceable parts. Instructions shall include name, address, telephone number of nearest manufacturer's representative, and nearest service and products or spare parts warehouse.

1. Shop Drawings: When Manuals include Shop Drawings and other information previously reviewed by the Engineer, include only the versions approved by the Engineer.

2. Warranties and Bonds: Include a copy of each, noting effective date for each warranty and bond.

1.7 MANUAL FOR MATERIALS AND FINISHES

A. Building Products, Applied Materials, and Finishes: Include:

1. Product Data: Including but not limited to:
 - a. Catalog number;
 - b. Size;
 - c. Composition or Material;
 - d. Color and texture designations;
 - e. Current unit price.
2. Product Reordering Instruction: Attach to Product Data

B. Instructions for Care and Maintenance: Include:

1. Manufacturers recommendations for cleaning agents and methods;
2. Precautions against detrimental agents and methods;
3. Recommended schedule for cleaning and maintenance.

C. Moisture Protection and Weather Exposed Products: Include:

1. Product data listing applicable reference standards, chemical composition, and details of installation.
2. Recommendations for inspections, maintenance, and repair.

D. Additional Requirements: As specified in individual product specification Sections,

1.8 MANUAL FOR EQUIPMENT AND SYSTEMS

A. For Each Item of Equipment and Each System Provide:

1. Description of unit or system, and component parts.
2. Identify:
 - a. Function
 - b. Normal operating characteristics, including startup and shut down procedures.
 - c. Limiting conditions, such as operational limits of time, speed, pressure, flow, temperature, etc.

- d. Safety considerations
 - e. Troubleshooting guide
- 3. Performance curves, with engineering data, test data, and test certifications.
- 4. Complete nomenclature and commercial number of replaceable parts.
- 5. Original manufacturer's parts list.
- 6. Original manufacturer's illustrations, assembly drawings, and diagrams required for maintenance.

B. Part Lists: Indicate:

- 1. Part number
- 2. Part description
- 3. Applicable serial numbers
- 4. Current unit prices.

C. Parts Ordering Instructions: Attach to Part Lists.

D. Parts Inventory: Attach to Part Lists recommendations as to spare parts and spare inventory levels, clearly identifying (e.g. by asterisks) the ones that are actually furnished. Where pertinent, recommend also:

- 1. Lead time
- 2. Shelf life
- 3. Preservation
- 4. Packing and labeling methods.

E. Exploded Drawings: To be utilized as necessary, to show equipment parts, identified by part numbers, with relation to other components of the equipment.

F. Operating Procedures: Include:

- 1. Start-up, break-in, and routine normal operating instructions and sequences;
- 2. Regulation, control, stopping, shut-down, and emergency instructions;
- 3. Any seasonal or special operating instructions.

G. Maintenance Requirements

- 1. Preventive Maintenance: Frequency and procedures for routine operations for preventive maintenance, including but not limited to:
 - a. Inspection

- b. Adjustment
- c. Lubrication
- d. Calibration
- e. Cleaning

2. Troubleshooting: Guide for troubleshooting, including but not limited to:
 - a. Disassembly, repair, and reassembly;
 - b. Alignment, adjusting and balancing,

H. Lubrication: Provide lubrication schedule, and list of lubricants required.

I. Sequence of Operation: Include sequence of operation by Instrumentation and Controls (I&C) manufacturer.

1. Panelboard Circuit Directories: Provide electrical service characteristics, controls and communications.

J. Electrical Schematics and Wiring Diagrams: Complete wiring between terminal points must be shown. Computerized diagrams are not acceptable.

K. Control Diagrams: Provide control diagrams by I&C manufacturer as installed.

L. Valves: Provide charts of valve tag numbers, with name and location of each valve, keyed to flow and control diagrams.

M. Quality Control: Provide test and balancing reports as specified.

N. Additional Requirements: As specified in individual product specification Sections.

PART 2 - PRODUCTS

Not Used

PART 3 - EXECUTION

Not Used

END OF SECTION

SECTION 09900

PAINTING AND PROTECTIVE COATING

PART 1 - GENERAL

1.1 SCOPE

- A. This section covers painting, complete. The term paint, used herein, includes enamels, epoxies, paints, sealers, bituminous protective coats, etc. It is intended to cover painting requirements for all parts of the project which are normally painted, as described herein or as required for a completely finished job. The requirements for both shop and finish painting are included herein.
- B. The object of these specifications is to provide the material and workmanship necessary to produce a first class job. Painting shall be done at such times as the Contractor and Engineer may agree upon in order that dust-free and neat work is obtained. All painting shall be done strictly in accordance with the manufacturer's instructions and shall be performed in a manner satisfactory to the Engineer.
- C. Field painting shall be done by the contractor and he shall be responsible for shop painting by various material and equipment suppliers.

1.2 QUALITY ASSURANCE

- A. All paints used on the site shall be clearly labeled showing manufacturer's name, product name and number, color and batch number.
- B. Field Quality Control shall consist of the following:
 - 1. Request review of first finished item or area.
 - 2. Use the first acceptable item or area as the project standard for the rest of the work.
 - 3. Each item or area used as a project standard shall be no smaller than 100 sq. ft. in surface area.
 - 4. Manufacturer's representative shall be available to advise applicator on proper application techniques and procedures.

1.3 RELATED SPECIFICATIONS

- A. Where references to painting materials or procedures are made under particular items of this contract, the provisions of such references shall prevail for that item, and shall take precedence over any provision of this section if such provisions conflict.

1.4 REFERENCE STANDARDS

- A. The following American Society for Testing and Materials (ASTM) specifications are included in these specifications by reference.
 - 1. ASTM D 2805, Contrast Ratio
 - 2. ASTM D 1308, Stain Resistance
 - 3. ASTM E 84, Surface Burning Characteristics of Building Materials
 - 4. ASTM D 522, Conical Mandrel Elongation
 - 5. ASTM D 2446, Freeze Thaw
 - 6. ASTM D 4585, Condensing Humidity
 - 7. ASTM D 3363, Hardness
 - 8. ASTM E 308, Light Reflectance
 - 9. ASTM B 117, Salt Spray
 - 10. ASTM D 3359B, Adhesion
 - 11. ASTM D 4060, Abrasion
 - 12. ASTM D 4541, Adhesion

- B. The following Federal Test Methods are included in these specifications by reference:
 - 1. Standard No. 141, Method 6271, Fungal Resistance
 - 2. Standard No 141, Method 6142, Scrubbability
 - 3. Standard No. TT-C-550C, Paragraphs 4.4.5.2. and 4.4.5.3., Stain Removal
 - 4. Standard No. TT-C-550C, Paragraph 4.4.6., Chemical Resistance
 - 5. Standard No. TT-C-555B, Paragraph 4.4.7.3., Wind Driven Rain

1.5 SURFACES TO BE PAINTED

- A. The items to be painted are indicated on the following list. This list includes the major portions of the work but does not necessarily include every item that will require painting. It is the intent to show that general overall painting is required under this contract.
 - 1. All structural steel and miscellaneous iron work.
 - 2. All piping, valves, gates, hangers, insulation, appurtenant equipment and miscellaneous items.
 - 3. All equipment and machinery including pumps, piping, instrumentation, etc.
 - 4. Electrical items, including steel conduits, electrical boxes, brackets, supports and similar items.
 - 5. All plumbing, heating and ventilating items.
 - 6. Building items including steel and wood, miscellaneous iron, drywall, carpentry and masonry.

- B. Work to be built into masonry and work inaccessible for final painting shall receive one field coat in addition to prime coat before erection.
- C. Aluminum work generally will not require painting except that contact surfaces of aluminum with concrete or dissimilar metals shall be given a thick coat of bituminous paint or other approved insulating material.

1.6 SURFACES NOT TO BE PAINTED

- A. Copper and bronze work (except pipes).
- B. Stainless steel surfaces.
- C. Steel and wrought iron to be embedded in concrete.

1.7 SUBMITTALS

- A. The Contractor shall submit the following items for approval prior to painting:
 - 1. Coating materials giving the manufacturer's name, product name & product line number for each material.
 - 2. Two copies of the manufacturer's technical data sheet for each coating, giving descriptive data, curing time, mixing, thinning and application instructions. Also provide a color selection chart.
 - 3. Color Samples:
 - a. Two samples of each color selected by the Owner for the project. One sample will be forwarded to the PWCSA for approval.
 - b. Prepare samples of clear and stained finished on the same type and grade of substrate specified for the project.
 - c. Make color sample at least 5" X 7" in size.
 - 4. Certificates: Manufacturer's certified test reports confirming compliance with specified performance requirements.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Materials shall be delivered in sealed containers with manufacturer's label intact.
- B. The Contractor shall store materials in a protected area at a temperature between 40F. and 110F.
- C. The Contractor shall take care to open and mix materials in storage area to avoid contamination.

1.9 ACCEPTABLE PAINTING CONDITIONS

- A. The Contractor shall apply coating only under the following prevailing environmental conditions:
 - 1. Air and surface temperatures not below 50F. or above 110F.
 - 2. Relative humidity not higher than 85% and the surface temperature at least 5°F above the dew point.
 - 3. Wind velocity under 15 mph for exterior spray painting.
 - 4. The atmosphere relatively free of airborne dust.
- B. The Contractor shall cover or otherwise protect surfaces not to be painted.

1.10 SAFETY

- A. The Contractor shall submit to the Owner/Engineer current manufacturer's product data sheets as well as Material Safety Data Sheets and shall have these documents available to his employees at the job site.
- B. The Contractor shall ensure that his employees are aware of any hazards peculiar to the job site, as well as location of first aid stations, emergency phone numbers and evacuation routes.
- C. The Contractor shall be responsible to report any condition which may pose a threat to the health and welfare of his employees to the Owner/Engineer.
- D. The Contractor shall keep his working area clean and safe and shall obey all job site rules and regulations.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Products specified herein are manufactured by Tnemec Company, Inc., North Kansas City, Missouri, and are specified as a standard of quality.
- B. Equivalent materials of other manufacturers may be substituted only by approval of the engineer/owner. Requests for substitution shall include manufacturer's literature for each product giving the name, generic type, descriptive information, solids by volume, recommended dry film thicknesses and a list of five projects where each product has been used and rendered satisfactory service. No request for substitution shall be considered that would decrease film thickness or offer a change in the generic type of coating specified. Manufacturer's certified test reports showing that the substitute product(s) equal or exceed the performance of the specified products shall be submitted.

C. Products for each specified function and system shall be of a single manufacturer.

2.2 MATERIALS

A. Approved Materials

1. Modified Acrylic Masonry Filler: Tnemec 130-6601 Envirofill
2. Hi-Build Polyamide Epoxy Primer and Finish: Tnemec 66 Hi-Build Epoxoline
3. Polyamine Epoxy Floor Sealer: Tnemec 281 Tneme-Glaze or Non-Skid
4. Aliphatic Acrylic Hi-Build Polyurethane Enamel: Tnemec 74 Endura-Shield
5. Modified-Acrylate Elastomer Coating (Sand and smooth finish): Tnemec 156-157 Enviro-Crete
6. Heat-Resistant Aluminum Coatings: Series 39 Silicone Aluminum
7. Alkyd Wood Primer: Series 36-603 Undercoater
8. Alkyd Enamel: Series 2H Hi-Build Tneme-Gloss
9. Emulsified Acrylic Coating: Series 6 and 7 Tneme-Cryl
10. Oil-Cementitious Exterior Coating: Series 22 Galv-Guard
11. Epoxy-Polyamide Primer: Series 160 Tneme-Fasprime
12. Epoxy-Polyamide Coating: Series 161 Tneme-Fascure
13. Polyamidoamine Epoxy Coating: Series 69 Hi-Build Epoxoline II
14. Polyamine Epoxy Floor Primer: Tnemec 201 Epoxoprime

B. Material Preparation

1. Mix and thin materials according to manufacturer's latest printed instructions;
2. Do not use mixed material beyond manufacturer's recommended pot life.

PART 3 - EXECUTION

3.1 PRE-WORK INSPECTION

- A. The Contractor shall examine surfaces to be coated and report any conditions that would adversely affect the appearance or performance of the coating systems and which cannot be put into an acceptable condition by the preparatory work specified in paragraph 12.2, and shall not proceed with surface preparation and application until the surface is acceptable or authorization to proceed is given by the engineer/owner.

3.2 SURFACE PREPARATION

A. General: The Contractor shall be responsible for the surface preparation of all items to be painted in accordance with the following recommendations:

1. Dislodge dirt, plaster nibs, mortar spatter and other dry material by scraping or brushing. Remove dust and loose material by brushing, sweeping, vacuuming or blowing with high-pressure air;
2. Remove oil, wax and grease by scraping off heavy deposits and cleaning with mineral spirits or a hot trisodium phosphate solution followed by a water rinse;
3. Verify that surfaces to be coated are dry, clean and free of dust, dirt, oil, wax, grease or other contaminants.

B. Concrete, Masonry and Cement Stucco:

1. Allow new concrete and masonry to cure 28 days.
2. Scrape or grind fins and protrusions flush with the surface.
3. Patch holes and cracks flush with the surface using a Portland cement grout or an approved patching material.
4. Rake mortar joints clean.
5. Remove surface laitance or efflorescence by acid etching or whip sandblasting.

C. Shop-primed Metal: Hand or power tool clean field connections, welds, burned and abraded areas to remove rust and contaminants and touch up with specified primer.

D. Ferrous Metal: Prepare surfaces in accordance with SSPC-SP6 commercial sandblast. NOTE: Coordinate with appropriate steel section. Example: Structural and miscellaneous metals.

E. Lightweight Metal: Prepare surfaces in accordance with SSPC-SP3 hand or power tool cleaning.

F. Galvanized Steel: Prepare surfaces by Solvent Cleaning in accordance with SSPC-SP1.

G. Non-Ferrous Metals: Prepare surface by Solvent Cleaning in accordance with SSPC-SP1.

3.3 APPLICATION

A. The Contractor shall be responsible for paint application in accordance with the following recommendations:

1. Mix and thin materials in accordance with the manufacturer's printed instructions.
2. Apply materials at specified film thickness by method recommended by the manufacturer.
3. Allow each coat to dry thoroughly before recoating.
4. Vary color slightly for each successive coat.
5. Cut in edges clean and sharp where work joins other materials or colors.
6. Make finish coats smooth, uniform in color, and free of brush marks, laps, runs, dry spray, overspray and skipped or missed areas.
7. Environmental conditions must comply with the recommended instructions of the manufacturer and be in accordance with the coating manufacturer's printed instructions.

3.4 INSPECTION

- A. The Contractor shall obtain field inspector's acceptance of each coat before applying succeeding coats and shall touch-up and repair all work that is not acceptable to the Engineer, prior to requesting final acceptance.

3.5 CLEANING

- A. The Contractor shall remove paint spatters from glass, plumbing fixtures and adjoining surfaces and shall repair any damage to coatings or surfaces caused by cleaning operations. He shall remove debris from job site and leave the area clean.

3.6 COATING SCHEDULE

- A. The surfaces to be painted under these specifications shall be coated in accordance with the following schedule:

1. Carbon Steel: Miscellaneous Metals, Tanks, Pipes, Equipment and Support Steel.
 - a. Exterior Non-Immersion

Surface Preparation: SSPC-SP6 Commercial Blast Cleaning.

Shop Primer: 160-1211 Tneme-Fasprime at 1.5-3.0 mils dft.

First Coat: 69-Color Hi-Build Epoxoline II at 4.0-6.0 mils dft.

Second Coat: 74 Color Endura-Shield at 3.0 - 5.0 mils dft.

Total Dry Film Thickness: 7.0 - 11.0 mils dft.

- b. Interior, Non-Immersion

Surface Preparation: SSPC-SP6 Commercial Blast Cleaning

Shop Primer: 160-1211 Tneme-Fasprime at 1.5-3.0 mils dft.

First Coat: 69-Color Hi-Build Epoxoline II at 4.0 - 6.0 mils dft.

Second Coat: 69-Color hi-Build Epoxoline at 4.0 - 6.0 mils dft.
Total Dry Film Thickness: 8.0 - 12.0 mils dft.

c. Immersion, interior or exterior non-potable or potable water (Note #1)

Surface Preparation: SSPC-SP10 Near White Blast Cleaning
Shop primer: 160-1211 Tneme-Fasprime at 1.5-3.0 mils dft

First Coat: 69-Color Hi-Build Epoxoline II (a) at 6.0 - 8.0 mils dft.
Second Coat: 69-Color Hi-Build Epoxoline II (a) at 6.0 - 8.0 mils dft.

2. Mill Coated Ductile Iron Pipe - Potable or non-potable

a. Exterior or Interior: Non-Immersion

Surface Preparation: Surface shall be clean and dry.
First Coat: 69-1211 Hi-Build Epoxoline II at 3.0 - 5.0 mils dft.
Second Coat: 69-Color HI-Build Epoxoline II at 4.0 - 6.0 mils dft.

b. Exterior or Interior: Immersion

Surface Preparation: SSPC-SP10 Near White Blast
First Coat: 69-1211 Hi-Build Epoxoline II at 5.0 - 7.0 mils dft
Second Coat: 69-Color Hi-Build Epoxoline II at 5.0 - 7.0 mils dft.

3. Galvanized Steel (Pipe, and Miscellaneous Fabrications)

a. Exterior

Surface Preparation: SSPC-SP1 Solvent Cleaning
First Coat: 66-Color Hi-Build Epoxoline at 2.0 - 3.0 mils dft.
Second Coat: 74-Color Endura-Shield at 2.0 - 3.0 mils dft.
Total Dry Film Thickness: 4.0 - 6.0 mils dft.

b. Interior

Surface Preparation: SSPC-SP1 Solvent Cleaning
Two Coats: 66-Color Hi-Build Epoxoline at 4.0 - 6.0 mils dft. (2.0 - 3.0 per coat)

c. Immersion: Non-Potable or Potable Water

Surface Preparation: SSPC-SP6 Commercial Blast
First Coat: 66-1211 Hi-Build Epoxoline at 3.0 - 5.0 mils dft.

Second Coat: 66-Color Hi-Build Epoxoline at 4.0 - 6.0 mils dft.

4. Concrete: Not used.
5. Concrete Masonry Unit (CMU)

- a. Interior

Surface Preparation: Surface shall be clean and dry.

First Coat: 130-6601 Enviro-Fill at 75 - 85 square feet per gallon.

Second Coat: 69-Color Hi-Build Epoxoline II at 4.0 - 6.0 mils dft.

Third Coat: 69-Color Hi-Build Epoxoline II at 4.0 - 6.0 mils dft.

Minimum Total Dry Film Thickness: 21.0 mils dft.

*Actual film thickness will depend on porosity of surface

6. Wood

- a. Interior/Exterior

Surface Preparation: Surfaces shall be clean and dry.

First Coat: 36-603 Undercoater at 2.0 - 3.5 mils dft.

Second Coat: 2H-Color Hi-Build Tneme-Gloss (Note #3) at 1.5 - 3.5 mils dft.

Third Coat: 2H-Color Hi-Build Tnemec-Gloss (Note #3) at 1.5 - 3.5 mils dft.

Total Dry Film Thickness: 7.0 - 11.0 mils dft. (Note #3) For semi-gloss finish, specify Series 23 Endura-Tone

7. PVC Pipe Exterior or Interior

- a. Interior/Exterior

Surface Preparation: Surface shall be clean and dry. Scarify surface area.

One Coat: 69-Color Hi-Build Epoxoline II at 4.0 - 6.0 mils dft.

END OF SECTION

SECTION 11000

GENERAL REQUIREMENTS FOR EQUIPMENT

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. **SCOPE:** This section specifies general requirements which are applicable to all mechanical equipment specified in Division 11. The Contractor is responsible for ensuring that all mechanical equipment meets the requirements of this section in addition to the specific requirements of the individual equipment specification section. Where the requirements of this section are in conflict with the requirements of an individual equipment specification section, the individual equipment specification shall take precedence.

In the event discrepancies exist between different plans, or between the plans and specifications and the Engineer is not so notified in writing before the date of the bid opening, the Engineer shall reserve the right to exercise sole arbitration authority.

B. **EQUIPMENT LISTS:** Equipment lists, presented in these specifications and as specified on the drawings, are included for the convenience of the Contractor and are not complete listings of all equipment, devices and material to be provided under this contract. The Contractor agrees to prepare his own material and equipment takeoff lists as necessary to meet the requirements of this project manual.

1.2 QUALITY ASSURANCE

A. **REFERENCES:** This section contains references to the following documents. They are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<u>REFERENCE</u>	<u>TITLE</u>
AFBMA STD 9-90	LOAD RATINGS AND FATIGUE LIFE FOR BALL BEARINGS
AFBMA STD 11-90	LOAD RATINGS AND FATIGUE LIFE FOR ROLLER BEARINGS
ANSI B1.1-89	UNIFIED SCREW THREADS
ANSI B1.20.1-83	PIPE THREADS, GENERAL PURPOSE (INCH)
ANSI B16.1-89	CAST IRON PIPE FLANGES AND FLANGED FITTINGS, CLASS 125

ANSI B18.2.1-81	CAST IRON PIPE FLANGES AND FLANGED FITTINGS, CLASS 250
	SQUARE AND HEX BOLTS AND SCREWS, INCLUDING ASKEW HEAD BOLTS, HEX CAP SCREWS, AND LOG SCREWS
ANSI B18.2.2-87	SQUARE AND HEX NUTS

- C. **UNIT RESPONSIBILITY:** Where specified in individual equipment specification sections, the Contractor shall assign unit responsibility to, and obtain each system from, the supplier of the primary or driven equipment. The supplier shall provide all components of the system to enhance compatibility, ease of construction and efficient maintenance. The responsible manufacturer shall coordinate selection and design of all system components such that all equipment is compatible and operates properly to achieve the performance requirements specified. Assignment of unit responsibility shall in no way relieve the Contractor of his responsibility to the Owner for performance of all systems as provided elsewhere in the Contract Documents.
- D. **WARRANTY:** All equipment and systems specified in Division 11 shall be warranted against defects in materials and workmanship for a period beginning from date of purchase and extending to one (1) full year from date of startup. During the warranty period, the equipment will be repaired or replaced at no cost to the Owner.

1.3 SUBMITTALS

- A. Provide the following submittals, as applicable, for each unique equipment item and unique set of performance requirements in accordance with Section 01300. Items 1 through 10 listed below must be submitted, reviewed by the engineer, and accepted, prior to shipping of equipment.
 1. Manufacturer's data including materials of construction, equipment configuration, details of installation and equipment weight.
 2. Dimensioned fabrication drawings showing the entire assembly. This shall include a materials list, sizes, piping connections, ASTM designations where appropriate, thicknesses, construction, and description of all major components.
 3. A copy of the contract document control diagrams and process and instrumentation diagrams, with addenda updates that apply to the equipment, marked to show specific changes necessary for the supplied equipment. If no changes are required, the drawing(s) shall be marked "no changes required."
 4. A copy of the individual equipment specification section with addenda updates that apply to the equipment specification section, with each paragraph check marked to show specification compliance or marked to show deviations.

5. Electrical data and control and wiring diagrams.
6. Pump performance curves and data, marked to indicate the operating limits recommended for stable operation between which the equipment may be operated without surge, cavitation, or vibration.
7. Certified factory test data as specified where required in the individual equipment specification.
8. Warranty information.
9. In the operation and maintenance manual submittal include the following:
 - Equipment Record Form as specified in Section 01300.
 - Motor Data Form as specified in Section 11060.
 - Manufacturer's Installation Certification Form.
 - Manufacturer's Instruction Certification Form. To be completed and signed after Training has been completed.
10. Submit operation and maintenance manuals as specified in Section 01730, accompanied by an O&M Manual Transmittal Form.
11. Proposed on-site testing and start-up procedures in step-by-step detail in accordance with Section 01650. Submittal of all test reports.

PART 2 – PRODUCTS

2.1 FLANGES AND PIPE THREADS

- A. Flanges on equipment and appurtenances provided under this section shall conform in dimensions and drilling to ANSI B16.1, Class 125 for maximum normal operating pressures of 150 psi or ANSI B16.1, Class 250 for maximum normal operating pressures of 300 psi, unless otherwise specified. Pipe threads shall conform in dimension and limits of size to ANSI B1.1, coarse thread series, Class 2 fit.
- B. Threaded flanges shall have a standard taper pipe thread conforming to ANSI B1.20.1. Unless otherwise specified, flanges shall be flat faced.
- C. Flange assembly bolts shall be heavy pattern, hexagonal head, carbon steel machine bolts with heavy pattern, hot pressed, hexagonal nuts conforming to ANSI B18.2.1 and B18.2.2. Threads shall be Unified Screw Threads, Standard Coarse Thread Series, Class 2A and 2B, ANSI B1.1.

2.2 BEARINGS

- A. Unless otherwise specified, equipment bearings shall be oil or grease lubricated, ball or roller type, designed to withstand the stresses of the service specified. Each bearing shall be rated in accordance with the latest revisions of AFBMA Methods of Evaluating Load Ratings of Ball and Roller Bearings. Unless

otherwise specified, equipment bearings shall have a minimum L-10 rating life of 50,000 hours. The rating life shall be determined using the maximum equipment operating speed.

- B. Grease lubricated bearings, except those specified to be factory sealed and lubricated, shall be fitted with easily accessible grease supply, flush, drain and relief fittings. Extension tubes shall be used when necessary. Grease supply fittings shall be standard hydraulic alemite type.
- C. Oil lubricated bearings shall be equipped with either a pressure lubricating system or a separate oil reservoir type system. Each oil lubrication system shall be of sufficient size to safely absorb the heat energy normally generated in the bearing under a maximum ambient temperature of 60 degrees C and shall be equipped with a filler pipe and an external level indicator gage.
- D. All bearings accessible to touch and located within 7 feet measured vertically from floor or working level or within 15 inches measured horizontally from stairways, ramps, fixed ladders or other access structures shall either incorporate bearing housings with sufficient cooling to maintain surface temperature at 65 degrees C or less for continuous operation at bearing rated load and a 50 degrees C ambient temperature or appropriate shielding shall be provided that will prevent inadvertent human contact.

2.3 V-BELT ASSEMBLIES

- A. Unless otherwise specified, V-belt assemblies shall be Dodge Dyna-V belts with matching Dyna-V sheaves and Dodge Taper-lock bushings, Wood's Ultra V-belts with matching Ultra-V sheaves and Wood's Sure-Grip bushings, or equal.
- B. Sheaves and bushings shall be statically balanced. Additionally, sheaves and bushings which operate at a peripheral speed of more than 5500 feet per minute shall be dynamically balanced. Sheaves shall be separately mounted on their bushings by means of three pull-up grub or cap tightening screws. Bushings shall be key seated to the drive shaft.
- C. Belts shall be selected for not less than 150 percent of rated driver horsepower and, where two sheaves sizes are specified shall be capable of operating with either set of sheaves. Belts shall be of the antistatic type where explosion-proof equipment is specified.

2.4 PUMP SHAFT SEALS

- A. GENERAL: Seals for the backwash and high zone pump shafts shall be shaft packing. Unless specified otherwise, shaft packing shall conform to the requirements set forth in this section.

B. MECHANICAL SEALS:

1. **SINGLE CARTRIDGE SEAL:** balanced o-ring, multi-spring design with self-aligning faces, one piece investment cast gland with flush, quench and drain ports, 316 SS construction, carbon vs. silicon carbide faces, carbon restriction bushing in atmospheric side of gland. Single mechanical seals shall be AESSEAL SCUSI or CURC as recommended by the manufacturer on a pump by pump basis; seals by other manufacturers will not be accepted.
2. Pumps used for hazardous chemicals and or abrasive fluids shall be equipped with double mechanical seals with built-in barrier fluid ports unless otherwise specified or requested by Owner.
3. For submersible pumps use AESSEAL T05 or manufacturers equivalent double mechanical seals for abrasives and single mechanical seals for clean water.

C. SHAFT PACKING:

1. Where shaft packing is specified, stuffing boxes shall be tapped to permit introduction of seal liquid and shall hold a minimum of five rows of packing. Stuffing boxes shall be face attached. Stuffing box and shaft shall be suitable for field installation, without machining or other modifications, of the mechanical seal specified in paragraph 11000-2.4.B for the applicable pump and operating conditions.
2. Unless otherwise specified, lantern rings shall be bronze or Teflon, packing shall be die-molded packing rings of non-asbestos material suitable for the intended service and as recommended by the manufacturer, and glands shall be bronze, two piece split construction. Lantern rings shall be of two-piece construction and shall be provided with tapped holes to facilitate removal. Lantern rings shall be drilled and tapped 1/4 NC-20. Threaded lantern ring removal tools shall be provided with spare parts for each pump.

D. SEAL WATER REGULATING AND MONITORING SYSTEM

1. Seal water monitoring system shall be a complete unified component capable of controlling all necessary aspects of the seal water system for pumps or equipment utilizing a packing gland type, single mechanical type, or double mechanical type shaft seal. Complete monitoring system shall include the single component control unit, mounting stand or bracket and associated hardware, and all necessary hoses, quick couplings, check valves, hose nipples, and hose couplings required for a complete and functioning system.
2. The base of the control unit shall be constructed of 7/8" thick, 316 stainless steel, to accommodate fittings. Seal connections shall be 1/4" NPT for shaft sizes up to 2" diameter and pumped fluid temperature < 120 deg F. For shafts > 2" diameter or pumped fluid temperatures > 120 deg F, unit shall have min. 3/8" connections. Unit shall include a push button test and clean system for

the flow meter which can be activated while unit is in operation. Unit shall utilize orifice shaped valves to allow larger particles of dirt and debris to pass through without stopping the flow or plugging the unit. Pressure gauge shall be glycerin filled. Unit shall come equipped with an inductive low-flow alarm sensor that utilizes an AC signal (20-250 VAC/DC) to communicate to the process control system.

3. Complete seal water monitoring system as specified shall be John Crane (previously Safematic) Safeunit Model SFP or SFD, or approved equal. Unit shall be provided with connections as follows or per manufacturer's written instructions:

- a. Packing gland or single seal flush type seal water system

John Crane (previously Safematic) Safeunit Model SFP

1 connection – water supply to unit

1 connection – water supply from unit to the shaft seal

- b. Double mechanical type seal water system

John Crane (previously Safematic) Safeunit Model SFD

1 connection – water supply to unit

1 connection – water supply from unit to shaft seal

1 connection – water return from shaft seal to unit

1 connection – drain line from unit

2.5 COUPLINGS

- A. Unless otherwise specified in the particular equipment sections, equipment with a driver greater than 1/2 HP, and where the input shaft of a driven unit is directly connected to the output shaft of the driver, shall have its two shafts connected by a flexible coupling which can accommodate angular misalignment, parallel misalignment and end float, and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of a tire with synthetic tension members bonded together in rubber. The flexible member shall be attached to flanges by means of clamping rings and cap screws, and the flanges shall be attached to the stub shaft by means of taperlock bushings which shall give the equivalent of a shrunk-on fit. There shall be no metal-to-metal contact between the driver and the driven unit. Each coupling shall be sized and provided as recommended by the coupling manufacturer for the specific application, considering horsepower, speed of rotation, and type of service.
- B. Where torque or horsepower capacities of couplings of the foregoing type is exceeded, Thomas-Rex, Falk Steel Flex, or equal, couplings will be acceptable provided they are sized in accordance with the equipment manufacturer's recommendations and sizing data are submitted. They shall be installed in conformance to the coupling manufacturer's instructions.

2.6 GUARDS

- A. Exposed moving parts shall be provided with guards which meet the requirements of OSHA. Guards shall be fabricated of 14-gage steel, 1/2-13-15 expanded metal screen to provide visual inspection of moving parts without removal of the guard. Guards shall be galvanized after fabrication and shall be designed to be readily removable to facilitate maintenance of moving parts. Reinforced holes shall be provided. Lube fittings shall be extended through guards.

2.7 CAUTION SIGNS

- A. Equipment with guarded moving parts which operates automatically or by remote control shall be identified by signs reading "CAUTION - AUTOMATIC EQUIPMENT MAY START AT ANY TIME". Signs shall be constructed of fiberglass material; minimum 1/8 inch thick, rigid, suitable for post mounting. Letters shall be white on a red background. The sign size shall be a minimum of 8 inches high by 12 inches wide. Signs shall be installed near guarded moving parts.

2.8 GAGE TAPS, TEST PLUGS, AND GAGES

- A. Gage taps shall be provided on the suction and discharge sides of pumps, blowers and compressors. Pressure and vacuum gages shall be provided where specified.

2.9 NAMEPLATES

- A. A manufacturer's nameplate shall be provided for each piece of equipment and shall identify the manufacturer's name and address, and the specific style and/or model of the equipment provided.
- B. Project identification nameplates shall be provided on each item of equipment and shall contain the specified equipment name or abbreviation and equipment number. Equipment nameplates shall be engraved or stamped stainless steel and fastened to the equipment in an accessible location with stainless steel screws or drive pins.
- C. Project identification nameplates for pumps shall indicate rated head and flow, pump operating speed (rpm), and impeller diameter.

2.10 LUBRICANTS

- A. The Contractor shall provide for each item of mechanical equipment a supply of the lubricant required for the commissioning period. Lubricants shall be of the type recommended by the equipment manufacturer and shall be products of the Owner's current lubricant supplier. The Contractor shall limit the various types of lubricants by consolidating them, with the equipment manufacturer's approval, into the least number of different types. Not less than 90 days before the date shown in his construction schedule for starting, testing and adjusting equipment,

the Contractor shall provide the Owner with three copies of a list showing the required lubricants, after consolidation, for each item of mechanical equipment. The list shall show estimated quantity of lubricant needed for a full year's operation, assuming the equipment will be operating continuously.

2.11 ANCHOR BOLTS

- A. Anchor bolts shall be designed for lateral forces for both pullout and shear. Anchor bolts shall be 304 Stainless Steel.

2.12 SPARE PARTS

- A. Spare parts, wherever required by detailed specification sections, shall be stored in accordance with the provisions of this paragraph. Spare parts shall be tagged by project equipment number and identified as to part number, equipment manufacturer, and subassembly component (if appropriate). Spare parts subject to deterioration such as ferrous metal items and electrical components shall be properly protected by lubricants or desiccants and encapsulated in hermetically sealed plastic wrapping. Spare parts with individual weights less than 50 pounds and dimensions less than 2 feet wide, or 18 inches high, or 3 feet in length shall be stored in a suitable box, identified with stenciled lettering stating the name of the equipment, equipment numbers, and the words "spare parts." A neatly typed inventory of spare parts shall be taped to the exterior of the box.

PART 3 – EXECUTION

3.1 GENERAL

- A. The manufacturer shall assume responsibility for packaging to prevent transit and handling damage.
- B. Final coatings, where required, shall be in accordance with Section 09900.

3.2 FIELD TESTING

- A. Provide factory certified service technician to inspect the installation, unless otherwise specified.
- B. All equipment shall be field tested after installation, in accordance with Section 16030, the Contract Documents, the requirements of this section, and the requirements of the individual equipment specification, to demonstrate satisfactory operation and performance, without causing excessive noise, cavitation, vibration, leakage, overheating, or other operational deficiencies. Field testing shall be performed under the supervision of an experienced field representative of the manufacturer, who shall supervise the testing and shall certify in writing that the equipment and controls have been properly installed, aligned, lubricated, adjusted, and readied for operation.

- C. Start-up. Start-up, check and operate equipment over the entire operational range and speed range.
- D. Pump systems. Pumps systems shall be tested for compliance with the following:
 1. Vibration shall be within amplitude limits recommended in the Hydraulic Institute Standards and shall be recorded at a minimum of four pumping conditions defined by the engineer.
 2. Pump performance shall be documented by obtaining concurrent readings, showing motor voltage, amperage, pump suction head, and pump discharge head for at least 4 pumping conditions. Each power lead to the motor shall be checked for proper current balance. All instrumentation necessary to conduct the testing shall be provided by the Contractor.
- E. The installation and initial operation of all components shall be certified on the Certificate of Installation, Inspection and Start-up Services form as specified in Section 01650. Complete forms specified in Section 01730 for Operation and Maintenance Manual.
- F. Electrical and controls testing shall conform to the requirements of Section 01650 and Division 16.

3.3 TRAINING

- A. Unless otherwise specified, training addressing the theory of operation, testing, troubleshooting, and maintenance of equipment item and system shall be provided. Training shall be conducted in accordance with Section 01650 and shall be certified on Manufacturer's Certificate of Instructional Services. Minimum training duration shall be as specified in the individual equipment specification.

END OF SECTION

11000-A. MANUFACTURER'S INSTALLATION CERTIFICATION FORM

Contract No: _____ Specification Section: _____

Equipment name: _____

Contractor: _____

Manufacturer of equipment item: _____

The undersigned manufacturer of the equipment item described above hereby certifies that he has checked the installation of the equipment and that the equipment, as specified in the project manual, has been provided in accordance with the manufacturer's recommendations and that the trial operation of the equipment item has been satisfactory.

Comments: _____

Date _____ Manufacturer _____

Signature of
Authorized Representative

Date _____ Contractor _____

Signature of
Authorized Representative

11000-B. MANUFACTURER'S INSTRUCTION CERTIFICATION FORM

Contract No.: _____ Specification Section: _____

Equipment name: _____

Contractor: _____

Manufacturer of equipment item: _____

The undersigned manufacturer certifies that a service engineer has instructed the facility's operating personnel in the proper maintenance and operation of the equipment designated herein.

Operations Check List (check appropriate spaces)

Start-up procedure reviewed

Shutdown procedure reviewed

Normal operation procedure reviewed

Others: _____

Maintenance Check List (check appropriate spaces)

Described normal oil changes (frequency)

Described special tools required

Described normal items to be reviewed for wear

Described preventive maintenance instructions

Described greasing frequency

Others: _____

Date

Manufacturer

Signature of
Authorized Representative

Date

Signature of
Owner's Representative

Date

Signature of
Contractor's Representative

SECTION 11060

ELECTRIC MOTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies low-voltage alternating current induction motors, 200 horsepower or less. This section does not specify medium voltage (over 600 volts) motors and specialty motors such as submersible motors, hoist motors, valve operator motors or torque rated motors. Unless specified otherwise, electric motors shall be provided by the manufacturer of the driven equipment under the provisions of Section 11000. Unless specified otherwise in the particular equipment specifications, motors shall be provided in compliance with this specification Section.

1.2 QUALITY ASSURANCE

A. General: Motors shall be built in accordance with UL 674, UL 1004, NEMA Standard MG 1, and to the requirements specified.

B. References: This section contains references to the following documents. They are a part of this section as specified and modified. In the event conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

<u>Reference</u>	<u>Title</u>
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry—Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 500 HP
NEMA ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA MG 1	Motors and Generators

<u>Reference</u>	<u>Title</u>
UL 674	Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 1004	Electric Motors
C.	<p>Testing: Motors rated 100 horsepower and greater shall be assembled and performance tested at the factory. Test results shall be submitted with the equipment operation and maintenance data. Factory tests shall include the following:</p> <ol style="list-style-type: none"> 1. No load current. 2. Full load current. 3. Breakdown torque. 4. Locked rotor current. 5. Locked rotor torque. 6. Hi-potential test.
1.3	SUBMITTALS
A.	<p>General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.</p> <ol style="list-style-type: none"> 1. Completed motor data form (Form 11060, appended to the end of this section). 2. For motors 100 horsepower and larger, a motor heating curve. 3. Motor outline, dimensions, and weight. 4. Motor connection diagram indicating requirements for all electrical connections. 5. Manufacturer's descriptive information relative to motor features and conformance with specified standards.
1.4	AMBIENT CONDITIONS
A.	<p>Motors shall be rated for continuous operation at nameplate horsepower under the following conditions:</p> <ol style="list-style-type: none"> 1. Temperature (max): 40 degrees Centigrade 2. Elevation: 1,000 feet above sea level.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. The following manufacturer's motors generally meet the class and performance requirements of this specification when furnished with appropriate modifications and additional features as specified:

1. Baldor
2. General Electric
3. Reliance Electric Co.
4. US Motor

2.2 GENERAL

A. Nameplates: Motor nameplates shall be engraved or stamped stainless steel or brass. Information shall include those items enumerated in NEMA Standard MG 1, paragraph 10.37, 10.38 or 20.60, as applicable. Nameplates shall be permanently fastened to the motor frame and shall be positioned to be easily visible for inspection.

1. Additional Markings:
 - a. Nameplates for motors 1/2 horsepower and larger shall indicate the ABMA L-10 rated life for the motor bearings.
 - b. Nameplates for motors 2 horsepower and larger shall list the NEMA nominal efficiency.
 - c. Nameplates for inverter duty motors shall identify the motor as inverter duty.
 - d. Nameplates for IEEE 841 compliant motors shall indicate IEEE 841 compliance.
 - e. Nameplates for explosion-proof motors shall also indicate UL frame temperature limit code.

B. Construction: All motors provided under this specification shall have the following features of construction unless otherwise specified:

1. Cast iron frames for motors 1/2 horsepower and larger. Steel frames for motors smaller than 1/2 horsepower. Aluminum frame motors will not be permitted.
2. Cast metal fan blades and shrouds.
3. Cadmium plated hardware.
4. Non-hygrosopic leads.
5. Class B temperature rise above 40 degrees C ambient.

6. NEMA design B.
7. NEMA F1 mounting configuration.

2.3 MOTORS LESS THAN 1/2 HORSEPOWER

- A. General: Motors less than 1/2 horsepower shall be squirrel cage, single phase, capacitor start, induction run type. Construction features listed in paragraph 11060-2.2 may be as normally supplied by the equipment manufacturer. Single phase motors shall have Class B insulation. Small fan motors may be split-phase or shaded-pole type. Windings shall be copper.
- B. Rating: Motors shall be rated 115 volts, single phase, 60 hertz, and shall be continuous-time rated in conformance with NEMA Standard MG 1, paragraph 10.35. Motors shall be non-overloading at all points of the equipment operation.
- C. Enclosures: Motor enclosures shall be as defined in NEMA MG 1. Unless otherwise specified, motors shall have totally enclosed fan cooled or totally enclosed non-ventilated enclosures. Explosion-proof motors shall bear the UL Label for Class I, Division 1, Group D hazardous locations.

2.4 MOTORS 1/2 HORSEPOWER THROUGH 250 HORSEPOWER

- A. General: Motors 1/2 horsepower through 250 horsepower shall be three phase, squirrel cage, full voltage start induction type. Unless otherwise specified, motors shall have a NEMA MG 1-1.16 design for the duty service imposed by the driven equipment such as frequent starting, intermittent overload, high inertia, mounting configuration, or service environment.
- B. Rating: Motors shall be rated 460 volts, three phase, 60Hz, and shall be continuous time rated in accordance with NEMA Standard MG 1, paragraph 10.35. Unless specified otherwise, motors shall have a service factor of 1.15, but shall not be required to exceed their nameplate rating at any point in the service range of the driven equipment.
- C. Efficiency: Motors shall be premium energy efficient type. Motor minimum nameplate efficiency, determined in accordance with IEEE 112B testing procedures, when operating on a sinusoidal power source shall be as specified in NEMA MG1 for premium efficiency electric motors.
- D. Classifications:
 1. General: Motors shall conform to the requirements specified in the following paragraphs. Definition of terms shall be in accordance with NEMA MG 1. Temperature rise for all motor types shall not exceed that permitted by Note II, paragraph 12.42, NEMA MG 1.
 2. Type 1 Motors: Type 1 motors shall have drip-proof guarded enclosures with Class F insulation and Class B temperature rise at the motor's nominal rating.

3. Type 2 Motors: Type 2 motors shall be totally-enclosed, fan-cooled with Class F insulation and Class B temperature rise at the motor's nominal rating.
4. Type 2S Motors: Type 2S motors shall be totally-enclosed, fan-cooled designed for severe duty applications. Type 2S motors shall conform to the requirements of IEEE 841. Motor nameplate shall indicate IEEE 841 compliance.
5. Type 3 Motors: Type 3 motors shall be explosion-proof motors, UL listed in accordance with UL 674 for Class I, Group D hazardous atmospheres. The motor shall have Class F insulation and shall conform to IEEE 841. An UL-approved breather/drain device shall be provided in the motor drain hole.

E. Thermal Protection: Type 2 and Type 3 motors, 50 horsepower and larger, shall be provided with Type 1 thermal protection as defined in NEMA MG 1-12.53.1 unless otherwise specified. Motor manufacturer shall provide any auxiliary equipment required to monitor the thermal protection devices. Auxiliary equipment shall have normally closed NEMA ICS 2 B300 contacts and shall be housed in NEMA 250 enclosures as follows:

1. Type 2 Motors: NEMA 4
2. Type 3 Motors: NEMA 7D

F. Inverter Duty Motors: Motors specified as inverter duty in the process equipment specifications shall have the features of the specified motor classification (Refer to paragraph 11060-2.4 D) in addition to the features specified herein for inverter duty motors.

Motors intended for use with adjustable frequency controllers shall not exceed NEMA MG1, Class B, temperature rise when operating over the specified speed range on the adjustable frequency controllers specified in Section 16269 with the specified load speed/torque characteristic. Inverter duty motors may be NEMA MG1-1.16, Design A.

Motors intended for use with adjustable frequency controllers shall be inverter duty motors specifically designed for inverter service for the speed range and load torque characteristic required by the associated driven equipment. Inverter duty motor shall be designed to operate over the speed or frequency range specified. Motor insulation shall be designed to meet NEMA MG 1, Part 31 (1600 volt peak at a minimum of 0.1 microsecond rise time).

Motors shall be premium energy efficient type with a minimum nameplate efficiency as specified in paragraph 11060-2.4 C at rated load on sine wave power at the base voltage and frequency rating. Motors shall have a 1.15 service factor on sine wave power at the base voltage and frequency rating and a 1.0 service factor on inverter power throughout the specified speed range.

1. Shaft Grounding Unit: Where specified, inverter duty motors shall be equipped with a shaft grounding unit mounted on the fan housing with stub shaft extended from the motor shaft. Grounding unit shall be equipped with two brushes, totally enclosed and sealed against environmental contamination.

2. Winding Overtemperature Protection: All inverter duty motors shall be provided with stator winding overtemperature protection. Overtemperature protection shall be NEMA MG 1-12.53, Type 1 winding and locked rotor overtemperature protection. Detectors shall be positive thermal protection (PTC) thermistors with leads brought out to a terminal block in an auxiliary conduit box integral to the motor. Thermistor characteristics shall comply with IEC 60034-11-2. Two thermistors shall be provided in each phase of the stator winding. All thermistor leads (2 per thermistor) shall be labeled and terminated in the motor auxiliary conduit box. Thermistor rating and configuration shall be compliant with the temperature protection relay specified in Section 16269.
3. Blower-Cooled Motors: Where specified, or required by the specified application requirements, inverter duty motors shall be totally enclosed, air-over, blower-cooled (TEBC). Blowers shall be driven at constant speed by 460-volt, 3-phase motors in conformance with Type 2 requirements as specified in paragraph 11060-2.4 D. Blower and ducting shall be an integral part of the main motor frame. Air intake filter shall be provided. Scroll case shall be cast aluminum or iron, and fan wheel shall be Type 304 stainless steel.

G. Vertical Motors: Vertical motors shall be solid-shaft P-base type specifically designed for vertical installation. Universal position motors are not acceptable. Vertical motors shall conform to Type 2, Type 3, and/or inverter duty motor requirements as specified. Thrust bearing rating shall be compatible with the loads imposed by the driven equipment.

H. Conduit Boxes: Conduit boxes shall be cast iron, split construction with threaded hubs. Conduit boxes shall be sized at least one size larger than NEMA standard for the given motor size. Conduit boxes shall be designed to rotate in order to permit installation in any of four positions 90 degrees apart. Motors shall be furnished with petroleum-resistant gaskets at the base of the conduit box and between the halves of the conduit box. Motors shall have grounding lug located within the box for the ground connection. Minimum length of pigtail leads shall be 12 inches for motors up to 50 horsepower, and 16 inches for motors larger than 50 to 250 horsepower.

A separate, auxiliary conduit box shall be provided for terminating the leads of internal motor accessories including thermal protective devices, space heaters, etc.

I. Bearings: Bearings may be oil or grease lubricated ball or angle contact roller bearings rated for a minimum L-10 life of 100,000 hours in accordance with ABMA 9-1990 or 11-1990 at the ambient temperature specified. Motor designs employing cartridge type bearings will not be accepted. Bearings shall be fitted with lubricant fill and drain or relief fittings.

J. Lifting Eyes: Motors weighing more than 50 pounds shall be fitted with at least one lifting eye.

K. Current Imbalance: Current imbalance, based upon the lowest value measured, shall not exceed the values tabulated below when the motor is operating at any load within its service factor rating and is supplied by a balanced voltage system:

1. Under 5 horsepower: 25 percent
2. 5 horsepower and above: 10 percent

L. Space Heaters: Where specified, space heaters shall be sized and designed to prevent condensation inside the motor enclosure after shutdown. Heaters shall be cartridge or flexible wraparound type. Heaters shall be rated 120 volts, single phase, 60 Hz. The space heater rating in watts and volts shall be noted on the motor nameplate or on a second nameplate. Space heater terminals shall be brought to a separate terminal block or pigtails in the conduit box.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which motors are to be installed, and notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.2 INSTALLATION OF MOTORS

- A. Install motors and accessories in accordance with manufacturer's instructions. Manufacturer's installation instructions shall be available at the project site.
- B. Remove any slushing compound on shaft or other parts using a petroleum-type solvent.
- C. Remove shaft shipping braces after motor is placed in its final location.
- D. Install motor securely on firm, level foundation.
- E. Install shaft coupling or sheave in accordance with manufacturer's instructions. Do not modify motor shaft to accommodate coupling or sheave.
- F. Align the motor shaft with the load shaft. Meet the most stringent of the motor manufacturer's requirements for shaft alignment or the driven equipment manufacturer's requirements for shaft alignment.
- G. Verify that line voltage and phases agree with motor nameplate.
- H. Ground motors according to manufacturer's instructions and the requirements of Section 16050.
- I. Make electrical connections to motors using materials and methods in accordance with Section 16100. Use motor lead splicing kits to insulate and seal connections to leads.

3.3 FIELD INSPECTIONS AND TESTS

- A. Verify that motor is lubricated in accordance with manufacturer's instructions.
- B. Before energizing, turn motor shaft by hand to ensure free rotation.
- C. Verify that the area around motor fan cooling air inlets is free of debris that could be drawn into motor or motor fan during operation.
- D. Check external bolted connections for proper torque.
- E. Before energizing motor with driven equipment, verify proper alignment of motor shaft with load shaft. Provide alignment test report.
- F. Inspect and test motor installations in accordance with the requirements of Section 16030.

END OF SECTION

Form 11060
Motor Data Form

Driven Equipment Name: _____ Equipment Numbers: _____

Driven Equipment Description: _____

Driven Equipment Location: _____

Motor Nameplate Markings

Manufacturer: _____ Manufacturer Type: _____

Frame: _____ Horsepower: _____ Service Factor: _____

Volts: _____ Phase: _____ Temperature Rating: _____ °C

Full Load Amps: _____ Frequency: _____ Locked Rotor Amps: _____

Design Letter: _____ Code Letter: _____ Insulation Class: _____

RPM: _____ Time Rating: _____

Motor Efficiency

Motor Enclosure Type

Guaranteed minimum efficiency: _____ Open drip proof

Nameplate or nominal efficiency: _____ Totally-enclosed, fan-cooled

_____ Explosionproof (Class I, Division 1)

_____ Other: _____

Motor Construction Features

Inverter Duty (NEMA MG 1, Part 31):

YES	NO

Winding Overtemperature Protection (PTC Thermistors in each winding):

Cast Iron Frame:

IEEE 841 Compliant

NEMA Mounting Configuration:

Bearing Life (Hours):

SECTION 11447
ROTARY SCREW AIR COMPRESSORS

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Furnish helical screw air compressors and associated controls, air receiver tanks, filters, gauges, relief valves, drains, and appurtenances required to meet the air requirements of the microfiltration systems specifications.

1.2 QUALITY ASSURANCE

A. **MANUFACTURER'S EXPERIENCE.** Manufacturer shall have been regularly engaged in the business specified herein for at least 5 years. The equipment and all ancillary components shall be designed, supplied and warranted as a unit item by a single manufacturer or vendor.

B. **WARRANTY.** The complete system, including instrumentation and control system, accessories and components shall be warranted for 1 year after final acceptance and startup of the equipment. Provide copies of the manufacturer's warranty as part of the operation and maintenance material.

1.3 REFERENCES

A. This section references the following documents which are a part of this section as specified and modified. In case of conflict between the requirements of this section and those of the referenced documents, the more stringent requirements shall prevail.

<u>Reference</u>	<u>Title</u>
ANSI/AFBMA 11-90	Load Ratings and Fatigue Life for Roller Bearings
ASME/ANSI	International Boiler and Pressure Vessel Code
ASTM A48	Standard Specification for Gray Iron Castings
CAGI/PNEUROP	Acceptance Test Code for Electrically-Driven Packaged Displacement Air Compressors
ISO 1217	Displacement Compressor Performance Standards, Annex C
ISO 1940/ ANSI S2.19	Balance Quality Requirements of Rigid Rotors, Grade G2.5
ISO 9001	Quality Management System
ISO 2151	Compressors and Vacuum Pumps Noise Test Code

NEMA MG1	Motors and Generators
NEMA 250	Enclosures for Electrical Equipment (1,000 volts maximum)
NFPA 79	Electrical Standard for Industrial Machinery
UL 508A	Industrial Control Panels

1.4 SUBMITTALS

A. Provide the following additional submittals in accordance with Section 01300:

1. Manufacturer's catalogue information for the compressors and control panels including performance characteristics, dimensions, materials of construction and equipment weights.
2. Equipment control panel wiring diagram identifying all internal and face-mounted components and connections to remote equipment.
3. Motor data form 11060-A as specified in paragraph 11060-1.03.
4. Operation and maintenance manuals in accordance with specification Section 01730.

1.5 SERVICE AND ENVIRONMENTAL CONDITIONS

A. Air compressors shall be installed inside a reinforced concrete building which will be ventilated with filtered, tempered air. The compressor supply air will be drawn from inside the building. The range of environmental conditions are as follows:

1. Air temperature range: 40 to 100 degrees Fahrenheit
2. Location: Fauquier County, Virginia
3. Elevation 360 feet above mean sea level, approximately

1.6 EQUIPMENT SCHEDULE

<u>Item</u>	<u>Equipment No.</u>
Air compressor 1	CP1401
Air compressor 2	CP1402

1.7 PERFORMANCE AND DESIGN REQUIREMENTS

A. GENERAL

Air compressors shall be fully enclosed, belt-driven, single-stage, air cooled, oil flooded screw type. Air compressors shall be capable of continuous duty (24-hours per day) cycle. Air compressors shall include the following features:

1. Inlet Air Filter
2. Differential Pressure Oil System with Oil Cooler Air/Oil Separator with Oil Level Sight Glass
3. Oil Filter
4. V-Belt Drive with Tensioning Device
5. Load/No Load Capacity Control
6. Sound Attenuating Enclosure - CSA/UL, Sound level \leq 62 db
7. Factory Oil Fill-Food Grade Oil
8. Electro-pneumatic start/stop control
9. Motor Starter Mounted and Prewired
10. Emergency Stop Button
11. After-cooler & Moisture Separator
12. Dew-point Gauge

B. OPERATING CHARACTERISTICS

The compressors shall modulate air flow in response to system demand. If system demand falls below a percent of capacity set point, the compressors shall automatically run in an unloaded condition. The compressor shall automatically shut down after running in the unloaded condition for a selectable predetermined period of time. The compressors shall automatically restart, reload, and modulate inlet air flow in response to low system pressure. The two compressors shall operate in a lead-lag mode with automatic alternating selection of the lead compressor by an adjustable timer.

C. EQUIPMENT COMPONENTS

The compressors furnished under this section shall have the following equipment components and characteristics:

1. COMPRESSORS

Type	Single Stage Oil Flooded Rotary Screw
Capacity	16.5 cfm Free Air Delivery (FAD) at 150 psi
Working pressure	150 psi at outlet of Integrated Refrigeration
Air Dryer	
Efficiency	30.1 kW/100 cfm Total Specific Energy
Required	

Motor	5 horsepower, TEFC motor
Motor efficiency	87.5 percent at full load
Male rotor speed	6110 rpm
Noise	62 dB(A) ± 3 dB(A) per ISO 2151
Oil capacity	0.7 gals
Compressed air oil content	6 ppm (prior to filtration)

2. INTEGRATED REFRIGERATED DRYER

Pressure drop over dryer	2.2 psig
Total power consumption 100%; including fan)	0.3 kW at full load (ambient = 68°F; RH =
Cooling air flow	291 cfm
Refrigerant type free	R134A, (Tetrafluoroethane, CF ₃ CH ₂ F) CFC
Refrigerant amount	0.9 lbs

3. EXTERNAL FILTERS

DDX Coalescing Filter	0.1 ppm oil/water, 1 micron filter
PDX Coalescing Filter	0.01 ppm oil/water, 0.01 micron filter

4. RECEIVER

Manufacturer	Silvan or Manchester
Type	Vertical
Capacity	200 gallons
Rating	200 psi ASME Coded
Pressure Relief Valve	1/4-inch 200 psi 178 scfm
Pressure Gauge	4-inch 0-200 psi
Drain Valve	1/2-inch ball valve

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. Air compressor shall be Atlas Copco Model GX4 FF, full featured w/enclosure or Engineer approved equal.

2.2 MATERIALS

A. Compressors shall be constructed with the following materials:

<u>Component</u>	<u>Material</u>
Rotor Casing	ASTM A48 Cast Iron
Rotors	Forged or Machined Carbon Steel

Anti-friction bearings	AFBMA L-10 life of 55,000 hours, minimum
Lubricant	Synthetic Hydrocarbon

2.3 EQUIPMENT

A. GENERAL

Air compressors shall be designed for continuous operation. The air compressor shall be fully packaged including air compressor, drive motor starters, air cooled lubricant cooler and aftercooler, lubrication system, air-lubricant separator system, moisture separator with trap air discharge, intake filter with differential pressure indicator, and control system, all mounted on a common base and fully enclosed by a sound dampening enclosure. The unit shall be rigidly mounted with anchor bolts to a concrete foundation as recommended by the equipment manufacturer.

B. COMPRESSOR UNIT

1. **CASING:** The compressor air end shall be a cast iron housing with precision manufactured helical screw type rotors. The housing shall be air cooled. The rotor casing shall have a corrosive-resistant coating.
2. **ROTORS:** The rotors shall have high efficiency twin-shaft rotors with asymmetric design. Male rotor shall have five lobes and female rotor shall have six flutes. Rotors shall be dynamically balanced to provide vibration free operation. The male rotor shall be driven by a "V" belt power transmission drive. Female rotor shall be driven by the male rotor. Rotors shall have a corrosion resistant coating.
3. **BEARINGS:** Anti-friction bearings with a minimum AFBMA L-10 life of 55,000 hours shall be incorporated on each rotor. Radial loads shall be carried by cylindrical roller bearings. Axial loads shall be carried by tapered roller bearings.
4. **SEALS:** The air seals shall be floating ring type, self-adjusting and centering, and shall be constructed of stainless steel. The oil seals shall be threaded labyrinth type. The air and oil seals shall be individually vented to the atmosphere. The air and oil seal vents shall be separated by a floating ring type seal to prevent any possible contamination of the compressed air. The portion of the rotors in contact with the seals shall have a corrosion-resistant coating.
5. **COOLING SYSTEM:** The compressor package shall be equipped with aluminum finned tube style coolers to air cool the lubricant. A fan, driven by the drive motor, shall be provided to force air across the cooler. A thermal mixing valve shall be provided to mix lubricant that has gone through the cooler with uncooled lubricant to maintain the optimum lubricant injection temperature at the air end. The air cooled lubricant coolers shall be designed to allow the compressor to

operate in an ambient temperature of 110 degrees F without the compressor discharge temperature reaching the shutdown limit.

6. AFTERCOOLING SYSTEM: An air cooled aftercooler shall be provided as an integral part of the compressor package. The aftercooler shall be sized to reduce the temperature of the compressed air to within 15 degrees of ambient temperature.
7. LUBRICATION SYSTEM: Lubrication shall be by a pressure differential system without an oil pump. Adjustable minimum discharge pressure valve and full flow lube filter shall be provided. The lubricant shall contain no hazardous chemical substances and used lubricant shall be suitable for recycling along with other waste petroleum oil. A lubricant filter shall be provided.
8. AIR/OIL RESERVOIR/SEPARATOR: Reservoir shall be ASME coded and stamped and shall be complete with safety relief valve and automatic blowdown valve with muffler. A manual blowdown valve shall also be provided. The reservoir shall provide air/oil storage as well as contain the air/oil separator elements.

Oil separator shall be of the replaceable element type. Oil carry-over from the separator shall be a maximum of one part per million by weight with clean lubricant and separators.

9. CONTROL PANEL: An integral control panel shall be provided for each compressor mounted on the compressor enclosure. The control panel shall contain all control relays, indicating lights with control power transformer. Each compressor unit package shall include a main disconnect switch, fuses, and combination motor starters for the compressor motor. Each panel shall be wired to be controlled by the plant SCADA system. Panels shall be NEMA 12 construction. Contacts for compressor trouble alarm (normally closed) and for running status (normally open) shall be brought to remote terminals for remote alarm annunciation.

Gauges and indicators shall be provided to indicate the following conditions:

- a. Discharge air pressure
- b. Compressor discharge temperature
- c. High temperature shutdown
- d. Power on
- e. Running hours
- f. Operating mode
- g. Internal air/oil separator differential pressure
- h. Phase monitor indicator
- i. Compressor capacity gauge

10. **COMPRESSOR ENCLOSURE:** The compressor unit, including motor, shall be fully enclosed in a steel acoustical cabinet with removable doors to provide access for maintenance. The enclosure shall be factory primed and coated. The enclosed compressors shall comply with the specified noise limits.

C. COMPRESSOR CONTROL

The compressors shall be supplied with a control system as required for automatic lead-follow, modulation, and load-unload operation. The control system shall be integral to the compressor package and shall include an electropneumatic regulation system. The controls supplied by the manufacturer shall include motor starters with manual disconnect and control power transformer. Control power shall be 120 volt, single phase AC.

The compressor controls shall allow for full range modulation to match compressor output to air system demand by gradually opening or closing the compressor inlet valve from 125 to 140 psig. When the discharge pressure exceeds 125 psig, pressure is directed to a cylinder in the inlet valve that begins to close the valve. The inlet valve will be fully closed at 140 psi and the compressor shall be in the unloaded condition. Each compressor shall have an adjustable timer to shut down if the unloaded condition is maintained for the preset time period. When the compressor unloads, a signal shall be sent to the air/oil separator reservoir blowdown valve to open and release the reservoir pressure to atmosphere. A check valve shall prevent system pressure from entering the reservoir from the discharge side. With little or no pressure in the reservoir, and with the rotors running in a vacuum, the horsepower requirement shall drop to 13 to 19 percent of full load. The differential pressure between the vacuum in the air end and the atmospheric pressure in the reservoir shall be sufficient for proper lubrication while maintaining low unloaded horsepower.

The lead compressor shall not come back on-line until system pressure has dropped to 80 psi. If system pressure falls to 75 psi, the follow compressor will also come on-line. When pressure increases to 120 psi, the unload timers shall be energized. The follow compressor's timer shall be set so that the follow compressor comes off-line first. The lead compressor will have a 2-minute span to pick up load if necessary or to shut down without being affected by the follow compressor.

The following items shall cause an alarm and automatic shutdown of the compressors:

1. High discharge temperature--alarm and shutdown.
2. High discharge pressure--alarm and shutdown.

Any shutdown condition shall prevent the compressor from restarting automatically after alarm shutdown until reset. Time delay between alarm and shutdown shall be as recommended by the equipment manufacturer.

D. MOTOR

The compressors motors shall have the following characteristics:

1. Motor: 5 horsepower
2. Motor efficiency: 87.5 percent at full load
3. Motor speed: 3600 RPM, 460 volt, 3 phase
4. Service factor: 1.25
5. Insulation: Class F, Class B rise
6. Enclosure: TEFC

E. INLET FILTER-SILENCER

Each compressor shall be equipped with an inlet air filter and inlet silencer. The filter element shall be of the cleanable type. Each filter-silencer shall be provided with threaded or flanged connections and mounting brackets. Interior surfaces shall receive a rust-inhibitive coating and exterior surfaces shall be prime coated. Each filter-silencer shall be sized so that the back pressure produced will not adversely affect performance of the compressor to which it is connected.

F. DISCHARGE AIR SEPARATOR/FILTER:

The compressor supplier shall furnish in-line discharge air separator/filter assemblies. Separator housing shall conform to ASME Boiler and Pressure Vessel Code and shall be rated at 250 psig, minimum. The units shall be suitable for temperatures to 120 degrees F, and have automatic drains or traps to automatically discharge liquid and other contaminants.

2.4 SPARE PARTS

Requirements for spare parts shall be in accordance with specification Section 01760 and shall include the following items:

- 1 set--all gaskets and end seals
- 1 set--main bearings
- 1 set--special tools required for maintenance, if any
- 4 sets--filter elements

2.5 PRODUCT DATA

The following product data shall be provided:

1. Installation certification form 11000-A.
2. Training certification Form 11000-B.

PART 3 - EXECUTION

3.1 INSTALLATION

The air compressor and appurtenances shall be installed as shown and in accordance with manufacturer's written recommendations.

3.2 TESTING AND TRAINING

After completion of installation, the air compressor, controls, and accessories shall be completely tested to ensure compliance with the operating requirements specified in accordance with specification Section 01650. Each compressor and piece of equipment shall be provided with performance testing as part of its installed test. Eight (8) hours of training shall be provided for this equipment in accordance with specification Section 01650.

END OF SECTION

SECTION 16010
BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 16.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Coordination drawings.
3. Record documents.
4. Maintenance manuals.
5. Rough-ins.
6. Electrical installations.
7. Cutting and patching.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Division 16 Section "BASIC ELECTRICAL MATERIALS AND METHODS," for materials and methods common to the remainder of Division 16.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Section "SUBMITTALS."

B. Cover Sheet: The electrical related shop drawings and product data submittals shall be provided with a cover sheet that includes at a minimum the following information: Project name, Contractor name, electrical sub-contractor name, supplier name, Specification section or sheet reference, variation from plans (yes/no), Contractor approval, and electrical sub-contractor approval. A 5x3" empty rectangle shall be provided at the bottom of the page reserved for Engineer review stamp

- C. Increase, by the quantity listed below, the number of electrical related shop drawings and product data submitted, to allow for required distribution plus two copies of each submittal required, which will be retained by the Electrical Consulting Engineer.
 - 1. Shop Drawings - Initial Submittal: 1 additional blue- or black-line prints.
 - 2. Shop Drawings - Final Submittal: 1 additional blue- or black-line prints.
 - 3. Product Data: 1 additional copy of each item.
- D. Additional copies may be required by individual sections of these Specifications.
- E. Submittal Document Quality: Facsimile documents are prohibited. Submittals containing sheets copied from facsimile documents will be automatically Rejected and returned to Contractor without review. Also submittals containing poor quality copies will be automatically Rejected and returned to Contractor without review.
- F. Submittal Document Binding: Use report covers with 3-hole, dual-prong tang fasteners or slide fasteners. Velo- and comb bound documents are also acceptable. Use of 3-ring binders is not permitted and such submittals will be automatically Rejected and returned to Contractor without review.

1.4 COORDINATION DRAWINGS

- A. Prepare coordination drawings to a scale of 1/8"=1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
 - 1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:
 - a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 - b. Exterior wall and foundation penetrations.
 - c. Fire-rated wall and floor penetrations.
 - d. Equipment connections and support details.
 - e. Sizes and location of required concrete pads and bases.
 - 2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
 - 3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 - 4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communications systems components, and other ceiling-mounted devices.

1.5 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 1 Section "CONTRACT CLOSEOUT." In addition to the requirements specified in Division 1, indicate installed conditions for:
 - 1. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
 - 2. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

1.6 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 Section "CONTRACT CLOSEOUT." In addition to the requirements specified in Division 1, include the following information for equipment items:
 - 4. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 5. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 6. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 7. Servicing instructions and lubrication charts and schedules.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - PRODUCTS

2.1 ELECTRICAL EQUIPMENT IDENTIFICATION

- A. General: Nameplates shall be made from laminated phenolic plastic. The nominal size of the nameplates shall be 3/4 inch high by 2 inches long. Nameplates shall have white

backgrounds with 3/16-inch black letters. Nameplate engraving shall minimally identify the equipment or equipment served by the labeled device and shall be in complete English terminology as indicated on the Drawings. Nameplates shall be attached with epoxy based adhesive.

B. Legends: Descriptions given on the one-line diagrams and panel schedules shall be used as the basis for nameplate engraving. In addition to the English description, each nameplate shall also indicate the equipment or device tag number. Additional engraving legend requirements shall be as defined below. If abbreviations are required because of space limitations, abbreviations shall be submitted to the Engineer for approval.

C. Equipment: Nameplates shall be provided for the following equipment. Additional engraving requirements shall be as indicated in parenthesis for each equipment type.

1. Panelboards, electrical cabinets, and enclosures
2. Electrical switchgear, and switchboards
3. Motor control centers (Motor control center designation, and equipment served by individual unit)
4. Control panels
5. Control stations (indicating equipment controlled)
6. Power transfer equipment
7. Transformers (indicating power source and equipment served)
8. Disconnect, transfer, and bypass switches (indicating power source and equipment controlled)
9. Local motor starters (indicating power source and equipment controlled)
10. Adjustable frequency drives (indicating power source and equipment controlled)

PART 3 - EXECUTION

3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
 1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
7. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 16 Section "BASIC ELECTRICAL MATERIALS AND METHODS."
12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 CUTTING AND PATCHING

- A. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:
 1. Perform cutting, fitting, and patching of electrical equipment and materials required to:
 - a. Uncover Work to provide for installation of ill-timed Work.
 - b. Remove and replace defective Work.
 - c. Remove and replace Work not conforming to requirements of the Contract Documents
 - d. Install equipment and materials in existing structures.

- e. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer observation of concealed Work.
2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
6. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

END OF SECTION

SECTION 16030

TESTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to Work of this Section. Should there be any conflict between provisions or requirements elsewhere indicated and the provisions of this division, request written clarification by addendum prior to submission of bid or abide by the interpretation of the Engineer.

1.2 SUMMARY

- A. This section specifies the acceptance testing of electrical materials, equipment and systems. Contractor shall provide all labor, tools, material, power and other services necessary to provide the specified tests.

1.3 QUALITY ASSURANCE

- A. References: This section contains references to the International Electrical Testing Association (NETA), ATS-2009: Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems, copyright 2009. It is a part of this section as specified and modified. In case of conflict between the requirements of this section and those of said document, the requirements of this section shall prevail.

- B. Safety Requirements:**

1. Safety and Precautions: This specification does not include specific safety procedures. It is recognized that tests and inspections set forth by this specification may be potentially hazardous. Consequently, individuals performing these tests must be capable of conducting these tests in a safe manner and with complete knowledge of the hazards involved. Each person involved in this project must be provided with and use appropriate personal protective equipment
2. Safety practices shall comply with Section 5 of ATS-2009.

- C. Procedural Requirements: All testing work shall be performed in accordance with the following codes and standards except as specified otherwise herein:

1. Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems, ANSI/NETA ATS-2009.
2. Standard for Certification of Electrical Testing Personnel, ANSI/NETA ETT-2000.
3. National Electrical Code, ANSI/NFPA 70.
4. Recommended Practice for Electrical Equipment Maintenance, ANSI/NFPA 70B.
5. Electrical Safety Requirements for Employee Workplaces, NFPA 70E.

1.4 APPLICATION

A. Requirements for testing in accordance with this section are specified in this and other sections of Division 16. Where testing in accordance with this section is required, the required tests, including correction of defects where found, and subsequent retesting, shall be completed prior to energization of material, equipment or systems.

1.5 SUBMITTALS

A. General: Submit the following in accordance with the requirements of Section 01300.

1. Examples of test report forms for all specified tests including deficiency report forms.
2. Final test report.
3. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (in the margin adjacent to the beginning of the paragraph) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT AND MATERIALS

A. General: Test instruments shall be calibrated to references traceable to the National Institute of Standards and Technology and shall have a current sticker showing date of

calibration, deviation from standard, name of calibration laboratory and technician, and date recalibration is required.

B. NETA Compliance: Test equipment shall be in complete compliance with ATS-2009, Paragraphs 5.2 and 5.3.

PART 3 - EXECUTION

3.1 TEST DOCUMENTATION

A. Inspection and Test Procedures Documentation: Detailed description of the proposed inspection and test procedures to be performed by the independent testing firm shall be prepared and submitted in accordance with paragraph 16030-1.5. The inspection and test description shall also identify the test equipment required for each test.

B. Test Report Forms: Test report forms shall be prepared for all test procedures as specified herein. Test report forms which appropriately and completely address the ATS-2009 test procedures shall include, but not by way of limitation, the following information:

1. Electrical equipment description.
2. Electrical equipment identification number.
3. Electrical equipment nameplate data.
4. Electrical equipment settings.
5. Time and date of test.
6. Ambient conditions at time of test.
7. Inspection checklist and results.
8. Test results.
9. Test equipment used.
10. Remarks regarding test procedure or results, unusual or noteworthy observations, etc.
11. Name and signature of testing personnel.
12. Name and signature of test witness.

3.2 EQUIPMENT TESTING

A. General: The inspection and test procedures described by ATS-2009, Section 7 shall establish the minimum requirements for electrical equipment inspection and testing. Additional test procedures, beyond the scope of ATS-2009, Section 7, are defined herein and shall be conducted as specified.

B. The following types of equipment and/or systems shall be inspected and tested by the contractor.

1. Insulation Resistance Tests: Insulation resistance tests shall be performed on the following types of equipment or systems. Insulation resistance measurements shall be recorded on test report forms in compliance with specification 16030-3.1 B.
 - a. Low Voltage (600 volt maximum) Power and Control Conductors and Cables: Insulation resistance tests shall be performed on all circuits 120 volts and above except interior lighting and 120 volt receptacle circuits.
 - 1) Power and control conductor and cable insulation tests shall be performed in accordance with ATS-2009, Paragraph 7.3.2. Tests may be conducted with motors and other equipment connected, except that solid-state equipment shall be disconnected unless the equipment is normally tested by the manufacturer at voltages in excess of 1000 volts DC.
 - 2) The ambient temperature at which insulation resistance is measured shall be recorded on the test form.
 - 3) Test results shall be evaluated against the results for cables of same type and length. Test results of less than 50 megohms shall be investigated.
 - b. Signal Cables: All analog signal cables shall be tested as specified herein.
 - 1) The loop resistance of each signal pair or triad shall be measured. Any pair or triad exhibiting a loop resistance of less than or equal to 50 ohms shall be deemed satisfactory. For pairs with greater than 50 ohm loop resistance, the Contractor shall calculate the expected loop resistance considering loop length and intrinsic safety barriers if present. Loop resistance shall not exceed the calculated value by more than 5 percent.
 - 2) Each shield drain conductor shall be tested for continuity. Shield drain conductor resistance shall not exceed the loop resistance of the pair or triad.
 - 3) Each conductor (signal and shield drain) shall be tested for insulation resistance with all other conductors in the cable grounded.
 - 4) Instruments used for continuity measurements shall have a resolution of 0.1 ohms and an accuracy of better than 0.1 percent of reading plus 0.3 ohms. A 500 volt megohmeter shall be used for insulation resistance measurements.
2. Low Voltage Motor Tests (less than 50 horsepower):
 - a. Installed Motor Test: The Installed Motor Test Form, 16030-A, appended to end of this specification section, shall be completed for each motor after installation. Motors shall be tested and inspected in accordance with ATS-2009, Paragraph 7.15.1.

- b. Insulation Tests: Motors 50 horsepower and larger shall have their insulation resistance measured and recorded at the time of delivery.
- c. Motor Current Imbalance: Motor running current shall be measured on each phase with the motor operating under load. Current imbalance shall not exceed the values tabulated below when the motor is operating at any load within its service factor rating and is supplied by a balanced voltage system. Current imbalance shall be based on the lowest measured value.

Under 5 horsepower:	25 percent
5 horsepower and above:	10 percent
- d. Motors rated 120 volt AC shall not be required to be tested.

3. Prefunctional Checkout: Functional testing shall be performed in accordance with the requirements of this specification. Prior to functional testing, all protective devices shall be adjusted and made operative. Prior to energization of equipment, all system component tests shall be completed and the Contractor shall perform a functional checkout of the control circuit. Checkout shall consist of energizing each control circuit and operating each control, alarm or malfunction device and each interlock in turn to verify that the specified action occurs.

3.3 TEST RESULTS

- A. Minimum acceptable test values shall be as specified in this specification and ATS-2009. Where acceptable test values are not specified, the equipment manufacturers recommended test values shall be used.

3.4 TEST REPORT

- A. Test report shall be assembled as described in ATS-2009, Paragraph 5.4 and submitted in accordance with paragraph 16030-1.5. Test results shall be organized by equipment item or system with individual, labeled tab dividers to identify each. All system deficiencies and non-compliant test results identified in the final test report shall be acknowledged as corrected by the responsible testing entity.

END OF SECTION

Driven Equipment Number: _____ Date of Test: _____

Driven Equipment Description: _____

Driven Equipment Location: _____

Insulation Resistance Phase-to-Ground (megohms)

Phase A: **Phase B:** **Phase C:**

Full Load Current and Voltage Measurements

Phase A	_____	Phase AB	_____
Phase B	_____	Phase BC	_____
Phase C	_____	Phase CA	_____

Current Imbalance (percent):

Motor Nameplate Markings

Manufacturer: **Manufacturer Type:**

Frame: Horsepower: Service Factor:

Volts: _____ Phase: _____ Temperature Rating: _____ °C

Full Load Amps: Frequency: Efficiency: %

RPM: Design:

Other Markings :

SECTION 16050
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Supporting devices for electrical components.
2. Electrical identification.
3. Fuses.
4. Grounding.
5. Cutting and patching for electrical construction.
6. Concrete bases.
7. Touchup painting.

1.3 SUBMITTALS

A. Product Data: For fuses include manufacturer's technical data on features and performance.

B. Field Test Ground Reports: Submit written test reports to include the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve complying test results.

1.4 QUALITY ASSURANCE

A. Source Limitations: Provide fuses from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
 - 1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- C. Where electrical identification devices are applied to field-finished surfaces, coordinate installation of identification devices with completion of finished surface.
- D. Where electrical identification markings and devices will be concealed by acoustical ceilings and similar finishes, coordinate installation of these items before ceiling installation.
- E. Coordinate fuse rating with equipment nameplate limitations of maximum fuse size.

PART 2 - PRODUCTS

1.6 SUPPORTING DEVICES

- A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.
- B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
- C. Slotted-Steel Channel Supports: Flange edges turned toward web, and 9/16-inch diameter slotted holes at a maximum of 2 inches o.c., in webs.
- D. Raceway and Cable Supports: Manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring-steel clamps or click-type hangers.
- E. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.
- F. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Plugs have number and size of conductor gripping holes as required to suit individual risers. Body constructed of malleable-iron casting with hot-dip galvanized finish.

- G. Expansion Anchors: Carbon-steel wedge or sleeve type.
- H. Toggle Bolts: All-steel springhead type.
- I. Powder-Driven Threaded Studs: Heat-treated steel.

1.7 ELECTRICAL IDENTIFICATION

- A. Identification Devices: A single type of identification product for each application category. Use colors prescribed by ANSI A13.1, NFPA 70, and these Specifications.
- B. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape, not less than 1 inch wide by 3 mils thick.
- C. Tape Markers for Wire: Vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters.
- D. Engraved-Plastic Labels, Signs, and Instruction Plates: Engraving stock, melamine plastic laminate punched or drilled for mechanical fasteners 1/16-inch minimum thickness for signs up to 20 sq. in. and 1/8-inch minimum thickness for larger sizes. Engraved legend in black letters on white background.
- E. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide three lines of text with 3/8-inch high lettering on 2-inch high label; where four lines of text are required, use labels 2-1/2 inches high. Use white lettering on black field. Provide labels for all electrical equipment listed below. In general, all labels shall include riser diagram ID, amperage, voltage, number of phases/poles, and equipment served from (source). Provide additional information as listed below:
 1. Panelboards: MCB/MLO; Service Entrance.
 2. Transformers: equipment served by.
 3. Disconnect switches: equipment served by.
 - a. Provide label for all disconnects provided by Division 11, 15 or 16.
 4. Enclosed Circuit Breakers: equipment served by.
 - a. Provide label for all disconnects provided by Division 11, 15 or 16.
 5. Contactors.
 6. Control devices.
- F. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32 stainless-steel machine screws with nuts and flat and lock washers.

1.8 FUSES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper Industries, Inc.; Bussmann Div.
 - 2. General Electric Co.; Wiring Devices Div.
 - 3. Gould Shawmut.
- B. Cartridge Fuses:
 - 1. Characteristics: NEMA FU1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.
- C. Fuse Holders:
 - 1. Characteristics: Holder shall be either Class R fuse holders or have an approved rejection kit.

1.9 GROUNDING

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering grounding conductors and connectors that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Chance/Hubbell.
 - 2. Erico Inc.; Electrical Products Group.
 - 3. Ideal Industries, Inc.
 - 4. Kearney/Cooper Power Systems.
 - 5. O-Z/Gedney Co.; a business of the EGS Electrical Group.
 - 6. Thomas & Betts, Electrical.
- B. Grounding Conductors:
 - 1. For insulated conductors, comply with Division 16 "Conductors and Cables".
 - 2. Equipment Grounding Conductors: Insulated with green-colored insulation.
 - 3. Grounding Electrode Conductors: Stranded cable.
- C. Connector Products:
 - 1. Bolted Connectors: Bolted-pressure-type connectors, or compression type.
 - 2. Welded Connectors: Exothermic-weld type, in kit form, and selected per manufacturer's written instruction.

1.10 CONCRETE BASES

- A. Concrete bases/equipment pad for electrical equipment shall be constructed of minimum 28 day, 3000 psi concrete reinforced with 6"x6" 6/6 gauge welded wire mesh. Top and sides of pad shall be troweled to smooth finish, equal to those of the floors, with all exposed corners provided with 3/4" chamfer. Concrete base shall generally conform to the shape of the electrical equipment and shall be doweled into the concrete floor slab.

1.11 TOUCHUP PAINT

- A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.
- B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

PART 3 - EXECUTION

1.12 ELECTRICAL EQUIPMENT INSTALLATION

- A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.
- B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.
- D. Right of Way: Give to raceways and piping systems installed at a required slope.

1.13 ELECTRICAL SUPPORTING DEVICE APPLICATION

- A. Damp Locations and Outdoors: Hot-dip galvanized materials or nonmetallic, U-channel system components. Clamps shall be UL listed to support specified raceway materials (RSC, ARC, and PVC).
- B. Dry Locations: Steel materials. Clamps shall be UL listed to support specified raceway materials (RSC, ARC, and PVC).
- C. Support Clamps for PVC Raceways: Click-type clamp system.
- D. Selection of Supports: Comply with manufacturer's written instructions.

- E. Strength of Supports: Adequate to carry present and future loads, times a safety factor of at least four; minimum of 200-lb design load.

1.14 SUPPORT INSTALLATION

- A. Install support devices to securely and permanently fasten and support electrical components.
- B. Install individual and multiple raceway hangers and riser clamps to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assemblies and for securing hanger rods and conduits.
- C. Support parallel runs of horizontal raceways together on trapeze- or bracket-type hangers.
- D. Size supports for multiple raceway installations so capacity can be increased by a 25 percent minimum in the future.
- E. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.
- F. Install 1/4-inch diameter or larger threaded steel hanger rods, unless otherwise indicated.
- G. Spring-steel fasteners specifically designed for supporting single conduits or tubing may be used instead of malleable-iron hangers for 1-1/2-inch and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings and for fastening raceways to slotted channel and angle supports.
- H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.
- I. Simultaneously install vertical conductor supports with conductors.
- J. Separately support cast boxes that are threaded to raceways and used for fixture support. Support sheet-metal boxes directly from the building structure or by bar hangers. If bar hangers are used, attach bar to raceways on opposite sides of the box and support the raceway with an approved fastener not more than 24 inches from the box.
- K. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.
- L. Install sleeves for cable and raceway penetrations of concrete slabs and walls unless core-drilled holes are used. Install sleeves for cable and raceway penetrations of masonry and fire-rated gypsum walls and of all other fire-rated floor and wall assemblies. Install sleeves during erection of concrete and masonry walls.

M. Securely fasten electrical items and their supports to the building structure, unless otherwise indicated. Perform fastening according to the following unless other fastening methods are indicated:

1. Masonry: Toggle bolts on hollow masonry units and expansion bolts on solid masonry units.
2. New Concrete: Concrete inserts with machine screws and bolts.
3. Steel: Welded threaded studs or spring-tension clamps on steel.
 - a. Field Welding: Comply with AWS D1.1. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
4. Light Steel: Sheet-metal screws.
5. Fasteners: Select so the load applied to each fastener does not exceed 25 percent of its proof-test load.

1.15 IDENTIFICATION MATERIALS AND DEVICES

- A. Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations indicated in the Contract Documents or required by codes and standards. Use consistent designations throughout Project.
- C. Self-Adhesive Identification Products: Clean surfaces before applying.
- D. Tag and label circuits designated to be extended in the future. Identify source and circuit numbers in each cabinet, pull and junction box, and outlet box. Color-coding may be used for voltage and phase identification.
- E. Circuit Identification Labels on Outlet Boxes, Junction Boxes and Pull Boxes: Install labels externally.
 1. Outlet boxes (receptacles and switches) and exposed junction boxes: Pressure-sensitive, self-adhesive plastic label on faceplate. Use clear label with black letters.
 2. Concealed junction and pull boxes: Neat handwritten label using permanent black marker.
 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- F. Color-code 480/277-V 3-phase system feeder, and branch-circuit conductors throughout the electrical system as follows:
 1. Phase A: Brown.
 2. Phase B: Orange.
 3. Phase C: Yellow.

4. Neutral: Gray.
5. Ground: Green.

G. Color-code 208/120-V 3-phase system feeder, and branch-circuit conductors throughout the electrical system as follows:

1. Phase A: Black.
2. Phase B: Red.
3. Phase C: Blue.
4. Neutral: White.
5. Ground: Green.

H. Install engraved-laminated emergency-operating signs with white letters on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.

1.16 FUSE INSTALLATION

A. Application:

1. Motor Branch Circuits: Class RK5, time delay.
2. Other Branch Circuits: Class RK5, non-time delay.

B. Fuses shall be selected as to provide a fully selective system.

C. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

1.17 GROUNDING APPLICATION

A. In raceways, use insulated equipment grounding conductors.

B. Connections and Terminations:

1. Exothermic-Welded Connections: Use for connections to structural steel.
2. Equipment Grounding Conductor Terminals: Use bolted pressure clamps.

C. Equipment Grounding Conductors:

1. Comply with NFPA 70, Article 250, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NFPA 70 are indicated.
2. Install equipment grounding conductors in all feeders and circuits.
3. Telecommunication Systems: Provide grounding system as documented on plans.

D. Installation:

1. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjecting to strain, impact, or damage.

E. Connections:

1. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 - b. Make connections with clean, bare metal at points of contact.
 - c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 - d. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
 - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
2. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
3. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
4. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

1.18 CUTTING AND PATCHING

- A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces required to permit electrical installations. Perform cutting by skilled mechanics of trades involved.
- B. Repair and refinish disturbed finish materials and other surfaces to match adjacent undisturbed surfaces. Install new fireproofing where existing firestopping has been disturbed. Repair and refinish materials and other surfaces by skilled mechanics of trades involved.

1.19 CONCRETE BASES

- A. Provide concrete base/equipment pad for all floor mounted equipment including equipment mounted on legs or provided with support stands.

1.20 FIELD QUALITY CONTROL

- A. Inspect installed components for damage and faulty work, including the following:

1. Supporting devices for electrical components.
2. Electrical identification.
3. Grounding.
4. Concrete bases.

- B. Ground System Testing: Perform the following field quality-control testing:

1. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.

1.21 REFINISHING AND TOUCHUP PAINTING

- A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 9 Section "Painting."
 1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
 2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
 3. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

1.22 CLEANING AND PROTECTION

- A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.
- B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION

SECTION 16100
CONDUCTORS, RACEWAYS, AND WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Building wires and cables and associated connectors, splices, and terminations for wiring systems rated 600V and less.
2. Raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
3. Underground concrete-encased duct banks and handholes.
4. Wiring device: receptacles, switches, and device plates.

B. Related Sections include the following:

1. Division 7 Section "Firestopping."
2. Division 16 Section "Basic Materials And Methods" for raceways and box supports.

C. Definitions:

1. ARC: Aluminum rigid conduit.
2. EMT: Electrical metallic tubing.
3. FMC: Flexible metal conduit.
4. GFCI: Ground-fault circuit interrupter. Also referred to as GFI.
5. LFMC: Liquidtight flexible metal conduit.
6. RMC: Rigid metal conduit.
7. RNC: Rigid nonmetallic conduit.

1.3 SUBMITTALS

A. Product Data:

1. For wires and cables.

2. For raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
3. Ducts, including elbows, spacers, and fittings.
4. Handhole construction and hardware.
5. For receptacles, switches, and faceplates.

B. Shop Drawings: Include layout drawings showing components and wiring for nonstandard boxes, enclosures, and cabinets.

1.4 QUALITY ASSURANCE

- A. Listing and Labeling: Provide all products specified in this Section that are listed and labeled. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
- B. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access. Revise locations and elevations from those indicated, as required to suit field conditions, and as approved by Engineer or Architect.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store non-metallic raceway and ducts with supports to prevent bending, warping, and deforming. Deliver ducts intended for underground use to Project site with ends capped.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Wires and Cables:
 - a. American Insulated Wire Corp.; Leviton Manufacturing Co.
 - b. BICC Brand-Rex Company.
 - c. Southwire Company.
2. Connectors for Wires and Cables:

- a. AMP Incorporated.
 - b. General Signal; O-Z/Gedney Unit.
 - c. 3M Company; Electrical Products Division.
- 3. Metal Conduit and Tubing:
 - a. Grinnell Co.; Allied Tube and Conduit Div.
 - b. Spiraduct, Inc.
 - c. Wheatland Tube Co.
- 4. Nonmetallic Conduit and Tubing:
 - a. Anamet, Inc.; Anaconda Metal Hose.
 - b. Lamson & Sessions; Carlon Electrical Products.
 - c. Thomas & Betts Corp.
- 5. Conduit Bodies and Fittings:
 - a. Crouse-Hinds; Div. of Cooper Industries.
 - b. Hubbell, Inc.; Killark Electric Manufacturing Co.
 - c. Lamson & Sessions; Carlon Electrical Products.
 - d. O-Z/Gedney; Unit of General Signal.
- 6. Metal Wireways:
 - a. Hoffman Engineering Co.
 - b. The Austin Company.
 - c. Square D Co.
- 7. Boxes, Enclosures, and Cabinets:
 - a. Erickson Electrical Equipment Co.
 - b. Hoffman Engineering Co.; Federal-Hoffman, Inc.
 - c. Hubbell Inc.; Raco, Inc.
 - d. Thomas & Betts Corp.
- 8. Underground Precast Concrete Handoles:
 - a. Christy Concrete Products, Inc.
 - b. Utility Vault Co.
 - c. Quazite, Division of MMFG.
- 9. Nonmetallic Ducts and Accessories:
 - a. ElecSys, Inc.
 - b. Carlon Electrical Products.
 - c. Spiraduct/AFC Cable Systems, Inc.
 - d. Thomas & Betts Corp.

10. Wiring Device:

- a. Hubbell, Inc.; Wiring Devices Div.
- b. Leviton Manufacturing Co., Inc.
- c. Pass & Seymour/Legrand; Wiring Devices Div.

2.2 POWER CONDUCTORS AND CABLES

- A. UL-listed building wires and cables with conductor material, insulation type, cable construction, and rating as specified in Part 3 "Wire and Insulation Applications" Article.
- B. Conductor Material: Copper.
- C. Stranding: Solid conductor for No. 10 AWG and smaller; stranded conductor for larger than No. 10 AWG.
- D. Minimum size: #12AWG for power and lighting circuits.
- E. Connectors and Splices:
 - 1. UL-listed, factory-fabricated wiring connectors of size, ampacity rating, material, type, and class for application and service indicated. Comply with Project's installation requirements and as specified in Part 3 "Wire and Insulation Applications" Article.
 - 2. Push-in type splice connectors are prohibited.

2.3 SIGNAL CABLES

- A. General: Signal cable shall be provided for instrument signal transmission and other circuits as specified. Circuit shielding shall be provided in addition to cable shielding. Single circuit signal cable shall be provided in accordance with cable specification, Type TSP/TST unless otherwise specified.
- B. Cable System Type: Twisted shielded pair/ twisted shielded triad (TSP/TST).
 - 1. Description: single twisted, shielded pair or triad, 18 AWG, instrumentation and signal cable, UL listed.
 - 2. Voltage: 600 volts
 - 3. Conductor Material: Bare annealed copper; stranded in accordance with ASTM B8
 - 4. Insulation: 15 mil, 90 degree C, polyvinyl chloride (PVC) with 4 mil nylon conduit or jacket
 - 5. Lay: Twisted on a 2-inch lay
 - 6. Shield: 100 percent, 1.35 mil aluminum-Mylar tape with a 7-strand tinned copper drain wire
 - 7. Jacket: 45 mil Polyvinyl chloride (PVC)

8. Flame Resistance: UL 1277

C. Manufacturer(s): Belden #83702 or approved equivalent by Okonite.

2.4 RACEWAY AND BOXES

A. Metal Conduit and Tubing:

1. Rigid Steel Conduit: ANSI C80.1.
2. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch, minimum.
3. ARC: Comply with ANSI C80.5 and UL 6A.
4. LFMC: Flexible steel conduit with PVC jacket.
5. Fittings: NEMA FB 1; compatible with conduit/tubing materials.
 - a. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints
6. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

B. Nonmetallic Conduit and Tubing

1. RNC: NEMA TC 2, Schedule 40 or 80 PVC.
2. RNC Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

C. Metal Wireways:

1. Material: Sheet metal sized and shaped as indicated.
2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
3. Wireway Covers: Hinged type.
4. Finish: Manufacturer's standard enamel finish.

D. Outlet and Device Boxes:

1. Sheet Metal Boxes: NEMA OS 1.
2. Cast-Metal Boxes: NEMA FB 1, Type FD, cast box with gasketed cover.
3. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Pull and Junction Boxes:

1. Small Sheet Metal Boxes: NEMA OS 1.

2. Cast-Metal Boxes: NEMA FB 1, cast box with gasketed cover.
3. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C

F. Enclosures and Cabinets:

1. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
 - a. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage, and include accessory feet where required for freestanding equipment.

2.5 UNDERGROUND DUCTS AND UTILITY STRUCTURES

A. Ducts:

1. Rigid Nonmetallic Conduit: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by the same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

B. Handholes:

1. Fiberglass Reinforced Concrete Handholes: Constructed of polymer concrete and reinforced by heavy-weave fiberglass. Composite material shall be rated for no less than 8,000 lbs. Over a 10"x10" area and tested to temperatures of -50°F. Compressive strength should be no less than 11,000 psi. Covers shall have a minimum coefficient of friction of .5 and have a design load of minimum 15,000 lbs per 10"x10" area. Unit, when buried, shall be designed to support AASHTO H10 loading. Unless otherwise noted all boxes shall be provided with bolted covers.
2. Cover Legend: "ELECTRIC" or "COMMUNICATIONS" as required.

C. Accessories:

1. Duct Spacers: Rigid PVC interlocking spacers, selected to provide minimum duct spacings and cover depths indicated while supporting ducts during concreting and backfilling; produced by the same manufacturer as the ducts.
2. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Capable of withstanding temperature of 300 deg F without slump and of adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete,

masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

3. Warning Tape: Underground-line warning tape specified in Division 16 Section "Basic Electrical Materials and Methods."
- D. Concrete: Use 3000-psi-minimum, 28-day compressive strength and 3/8-inchmaximum aggregate size. Concrete and reinforcement are specified in Division 3 Section "Cast-in-Place Concrete."

2.6 WIRING DEVICES

- A. Straight-Blade and Locking Receptacles: Heavy-Duty industrial grade. Color: Ivory.
 1. NEMA 5-20R (standard #WDI.101968).
 2. Minimum 0.05" stainless steel strap and minimum 0.030" brass triple-wipe contacts.
 3. Arranged for back and side wiring.
 4. Grounding type. Separate single or double grounding terminals with screw lugs and a direct, green insulated conductor connector to system ground. Screw shall be green and hex-headed.
 5. Listed by an approved third party agency.
- B. GFCI Receptacles: Heavy-duty industrial grade termination type, with integral NEMA WD 6, Configuration 5-20R duplex receptacle. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter.
- C. Snap Switches: Heavy-duty, quiet type. Color: Ivory.
 1. 20A, 120/277v, AC only.
 2. Grounding type, with green hex-head grounding screw.
 3. Quiet type operating mechanism; shall not utilize mercury switches.
 4. Listed by an approved third party agency.
- D. Wall Plates: Single and combination types match corresponding wiring devices.
 1. Plate-Securing Screws: Metal with head color to match plate finish.
 2. Material for Finished Spaces: 0.04-inch- (1-mm-) thick, Type 302, satin-finished stainless steel.
 3. Material for Unfinished Spaces: Galvanized steel.
 4. Material for Wet Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

PART 3 - EXECUTION

3.1 CONDUCTORS AND CABLES

- A. Examination:** Examine raceways and building finishes to receive wires and cables for compliance with requirements for installation tolerances and other conditions affecting performance of wires and cables. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Wire and Insulation Applications:**
 - 1. Service Entrance: Type RHW or THWN, in raceway.
 - 2. Feeder: Type THHN/THWN, in raceway.
 - 3. Branch Circuits: Type THHN/THWN, in raceway.
 - 4. Class 2 Control Circuits: Type THHN/THWN, in raceway.
- C. Installation:** Install wires and cables as indicated, according to manufacturer's written instructions and NECA's "Standard of Installation."
 - 1. Pull Conductors: Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
 - 3. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
 - 4. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."
 - 5. Seal around cables penetrating fire-rated elements according to U.L. systems shown on drawings and Division 7 Section "Fireproofing."
 - 6. Identify wires and cables according to Division 16 Section " Basic Electrical Materials and Methods."
- D. Connections:**
 - 1. Conductor Splices: Keep to minimum.
 - 2. Install splices and tapes that possess equivalent or better mechanical strength and insulation ratings than conductors being spliced. Push-in type splice connectors are prohibited. Use splice and tap connectors compatible with conductor material.
 - 3. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.
 - 4. Connect outlets and components to wiring and to ground as indicated and instructed by manufacturer.

5. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.2 SIGNAL CABLES

- A. Circuits shall be run as individually shielded twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever 3-wire circuits are required. Terminal blocks shall be provided at instrument cable junctions, and circuits shall be identified at such junctions unless otherwise specified. Signal circuits shall be run without splices between instruments, terminal boxes, or panels. Signal cable terminations shall be prepared as indicated on the Drawings.
 1. Shields are not acceptable as a signal path, except for circuits operating at radio frequencies and utilizing coaxial cables.
 2. Common ground return conductors for two or more circuits are not acceptable.
 3. Unless otherwise specified, shields shall be bonded to the signal ground bus at the control panel and isolated from ground and other shields at other locations. Terminals shall be provided for running signal leads and shield drain wires through junction boxes.
 4. Spare circuits and the shield drain wire shall be terminated on terminal blocks at both ends of the cable run and be electrically continuous through terminal boxes. Shields or drain wires for spare circuits shall not be grounded at either end of the cable run.
- B. Terminal boxes shall be provided at instrument cable splices. If cable is buried or in raceway below grade at a splice, an instrument stand shall be provided as specified with terminal box mounted approximately 3 feet above grade.

3.3 RACEWAY AND BOXES

- A. Examination: Examine surfaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.
- B. Wiring Methods:
 1. Outdoors: Use the following wiring methods:
 - a. Exposed: Rigid galvanized steel.
 - b. Concealed: Rigid galvanized steel.
 - c. Underground, Single Run: RNC.
 - d. Underground, Grouped: RNC.

- e. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- f. Boxes and Enclosures: NEMA 250, Type 4, unless noted 4X on plans.

2. Indoors: Use the following wiring methods:

- a. Exposed:
 - 1) General: Aluminum rigid conduit (ARC).
 - 2) Corrosive Environment: Where noted on plans for corrosive or NEMA 4X environment provide Schedule 80 PVC.
 - 3) Stub-ups through concrete slab: PVC-coated rigid steel conduit.
- b. Concealed: Rigid steel conduit.
- c. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- d. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - 1) Damp or Wet Locations: NEMA 250, Type 4, metallic.
 - 2) Corrosive Environment: Where noted on plans for corrosive environment provide NEMA 4X, non-metallic.

C. Installation: Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions

- 1. Minimum Raceway Size: 3/4-inch trade size (DN21).
- 2. Conceal conduit, unless otherwise indicated, within finished walls, ceilings, and floors.
- 3. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- 4. Install raceways level and square and at proper elevations. Provide adequate headroom.
- 5. Complete raceway installation before starting conductor installation.
- 6. Support raceways as specified in Division 16 Section " Basic Electrical Materials and Methods."
- 7. Protect stub-ups from damage where conduits rise through floor slabs. Provide rigid galvanized steel elbows and extend rigid conduit a minimum of 4" above finished slab. Arrange so curved portion of bends is not visible above the finished slab.
- 8. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
- 9. Use raceway fittings compatible with raceways and suitable for use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings, unless otherwise indicated.
- 10. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.

11. Raceways Embedded in Slabs: Raceway shall not be installed embedded within floor and roof slabs.
12. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much as practical.
 - a. Run parallel or banked raceways together, on common supports where practical.
 - b. Make bends in parallel or banked runs from same centerline to make bends parallel. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
13. Join raceways with fittings designed and approved for the purpose and make joints tight.
 - a. Make raceway terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 - b. Use insulating bushings to protect conductors.
14. Terminations: Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against the box. Where terminations are not secure with 1 locknut, use 2 locknuts: 1 inside and 1 outside the box.
15. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with the finished floor. Extend conductors to equipment with LFMC. Install screwdriver-operated, threaded flush plugs for future equipment connections.
16. Flexible Connections: Use maximum of 6 feet (1830 mm) of flexible conduit forequipment subject to vibration, noise transmission, or movement; and for all motors. Use liquidtight flexible conduit in wet or damp locations. Install separate ground conductor across flexible connections.
17. Install hinged-cover enclosures and cabinets plumb. Support at each corner.

D. Protection: Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure coatings, finishes, and cabinets are without damage or deterioration at the time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.4 UNDERGROUND DUCTS AND UTILITY STRUCTURES

A. Applications:

1. Underground Ducts for Electrical Feeders: Type EPC-40-PVC.
2. Underground Ducts for Electrical Branch Circuits: Type EPC-40-PVC.
3. Underground Ducts for Communication Utility Service: Type EPC-40-PVC.

B. Earthwork:

1. Excavation and Backfill: Comply with Division 2 Section "Earthwork" but do not use heavy-duty, hydraulic-operated, compaction equipment.
2. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
3. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching.
4. Restore disturbed pavement. Refer to Division 1 Section "Cutting and Patching."

C. Conduit and Duct Installation:

1. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment.
2. Curves and Bends: Use manufactured elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 25 feet, both horizontally and vertically, at other locations.
3. Use solvent-cement joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.
4. Building Entrances: Make a transition from underground duct to conduit at least 5 feet outside the building wall. Use fittings manufactured for this purpose. Follow the appropriate installation instructions below:
 - a. Concrete-Encased Ducts: Install reinforcement in duct banks passing through disturbed earth near buildings and other excavations. Coordinate duct bank with structural design to support duct bank at wall without reducing structural or watertight integrity of building wall.
 - b. Waterproofed Wall and Floor Penetrations: Install a watertight entrance-sealing device with sealing gland assembly on the inside. Anchor device into masonry construction with one or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.
5. Concrete-Encased, Nonmetallic Ducts: Support ducts on duct spacers, spaced as recommended by manufacturer and coordinated with duct size, duct spacing, and outdoor temperature. Install as follows:
 - a. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts and secure separators to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6 inches between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - b. Concreting: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to

flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application. Pour each run of envelope between manholes or other terminations in one continuous operation. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing rod dowels extending 18 inches into concrete on both sides of joint near corners of envelope.

- c. Reinforcement: Reinforce duct banks where they cross disturbed earth and where indicated.
- d. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
- 6. Warning Tape: Bury warning tape approximately 12 inches above all concrete-encased duct banks. Align tape parallel to and within 3 inches of the centerline of duct bank.
- 7. Stub-ups: Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete bases, extend steel conduit a minimum of 5 feet from edge of base. Install insulated grounding bushings on terminations. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete.
- 8. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- 9. Pulling Cord: Install 100-lbf-test nylon cord in ducts, including spares.

3.5 WIRING DEVICES

A. Installation:

- 1. Install devices and assemblies plumb and secure.
- 2. Install wall plates when painting is complete.
- 3. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- 4. Protect devices and assemblies during painting.
- 5. Damp and Wet Locations:
 - a. Provide weather-resistant receptacles with weatherproof cover in damp and wet locations.
 - b. Provide additional weather-resistant receptacles with weatherproof cover as indicated on the plans.

B. Identification: Comply with Division 16 Section

- 1. Comply with Division 16 Section "Basic Electrical Materials and Methods."
- 2. Switches: Where three or more switches are ganged, and elsewhere as indicated, identify each switch with approved legend engraved on wall plate.

3. Receptacles: Identify panel board and circuit number from which served. Use machine-printed, pressure-sensitive, abrasion-resistant label tape on face of plate and durable wire markers or tags within outlet boxes.

C. Connections:

1. Connect wiring device grounding terminal to outlet box with bonding jumper.
2. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
3. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

A. Conductors and Cables:

1. Testing: On installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
2. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.
3. Correct malfunctioning conductors and cables at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

B. Underground Ducts and Utility Structures:

1. Duct Integrity: Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of the duct. If obstructions are indicated, remove obstructions and retest.
2. Correct installations if possible and retest to demonstrate compliance. Remove and replace defective products and retest.

C. Wiring Devices:

1. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
3. Replace damaged or defective components.

3.7 CLEANING

- A. Raceway and Boxes: On completion of installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finish, including chips, scratches, and abrasions.
- B. Underground Ducts: Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- C. Wiring Devices: Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION

SECTION 16269
ADJUSTABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies low voltage adjustable frequency drive (AFD) systems. The AFD system shall be a factory engineered and integrated system including incoming line reactors, rectifier, inverter, control circuitry, protective equipment, and accessories as necessary to provide the specified functions and assembled in an individual enclosure. AFDs shall employ pulse width modulated inverter technology and shall be the product of single manufacturer.

1.2 RELATED DOCUMENTS

A. Drawings and General Provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to Work of this Section. Should there be any conflict between provisions or requirements elsewhere indicated and the provisions of this division, request written clarification by addendum prior to submission of bid or abide by the interpretation of the Engineer.

B. The following Specifications are related to Work described in this Specification section. This list of related specifications is provided for convenience only and is not intended to excuse or otherwise diminish the duty of the Contractor to see that the completed Work complies accurately with the Contract Documents.

1. Section 16300, Motor Controllers.

C. Adjustable Frequency Drives Summary, Table 16269-A, appended to the end of this specification section applies to Work of this Section.

1.3 SUBMITTALS

A. General: Submit the following:

1. Manufacturer's catalog data indicating equipment specifications and construction features including all optional equipment and features proposed.
2. Unit descriptions including amperage ratings, enclosure ratings, circuit breaker frame sizes, fault ratings, breaker continuous amperage ratings, etc., as required for approval.

3. Outline dimensions, shipping section dimensions, weight, conduit routing locations, and foundation requirements for all assemblies.
4. Elementary connection and interconnection diagrams in accordance with JIC EMP 1 and NEMA ICS standards. Diagrams shall indicate the interconnection of all AFD components including door-mounted control devices and the function and identification of all field terminals.
5. Dimensioned layout drawings indicating equipment layout on AFD enclosure door and interior equipment mounting panel. Layout drawings shall include an engraving legend for all panel nameplates.
6. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (in the margin adjacent to the beginning of the paragraph) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. The submittal shall be accompanied by a detailed, written justification for each deviation. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in the manufacture of AFDs of types, sizes, and ratings required, whose products have in satisfactory use in similar service for not less than 10 years. The manufacturer of the AFD assembly shall be the manufacturer of the major components within the assembly.
- B. Commissioning and Training: AFDs shall be inspected and commissioned by a field service engineer in the direct employment of the AFD manufacturer. AFD operation and maintenance training shall be conducted by a factory-trained instructor in the direct employment of the AFD manufacturer.
- C. Codes and Standards: AFDs shall comply with the applicable requirements of NEMA ICS 3 and additional standards referenced by ICS 3 and those listed herein. The AFD manufacturer shall furnish the product as listed and classified by Underwriter's Laboratories as suitable for the purpose specified and indicated. AFD assemblies shall be designed, manufactured, and tested in accordance with the latest applicable standards of NEMA, ANSI, and UL.

1. National Electrical Code, NFPA 70.
2. IEEE 519 - Recommended Practices for Harmonic Control in Electrical Power Systems
3. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
4. NEMA ICS 2 - Industrial Control Devices, Controllers and Assemblies
5. NEMA ICS 3 - Industrial Systems
6. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Variable Speed Drive Systems
7. UL 508C - Power Conversion Equipment

D. Manufacture and Assembly: AFDs shall be completely factory assembled in the specified enclosure system by the manufacturer of the AFD.

1.5 ENVIRONMENTAL CONDITIONS

A. General: AFDs shall be rated for continuous operation in the specified configuration in an ambient temperature of 85 to 20 degrees C at the project site elevation of 360 feet above sea level.

PART 2 - PRODUCTS

2.1 ACCEPTABLE PRODUCTS

A. General: AFD systems shall convert 460 volt, 60 hertz nominal input power to a suitable voltage and frequency to cause a standard squirrel-cage induction motor to run at a speed proportional to an external reference signal. AFDs and all internal components shall be suitable to serve the loads specified under the conditions specified.

B. Manufacturers: AFDs specified in this Specification shall be the product of a single manufacturer. AFDs are specified on the basis of the following products for function and quality. Supply products modified as necessary by the manufacturer to provide the specified features and to meet specified operating conditions.

1. Eaton, SVX9000
2. Allen-Bradley, PowerFlex 755
3. Approved Equal

2.2 CONSTRUCTION

A. Enclosures: Enclosures shall be suitable for indoor service and shall have a NEMA 250 Type 1 sealing rating. Enclosures shall be fabricated using 12-gage (minimum) sheet

steel. Enclosures shall be provided with an interior frame or otherwise formed so as to provide a rigid structure. AFD system individual enclosures shall be front accessible and shall not require rear access. Individual enclosures shall be designed for wall mounting, or free-standing applications. Individual enclosures shall be suitable for mounting directly against a wall without any clearance for ventilation or any other purposes. Enclosures shall be arranged for entry of incoming line and load cables as required for each application. AFD system individual enclosure finish shall be dry polyester powder coating of manufacturer's standard color. Interior color shall be white.

B. Wiring:

1. Power Wire: Power wire shall be copper 90 degrees C "MTW" insulated, sized to suit load; minimum power wire size shall be No. 12 AWG, stranded.
2. Control Wire: Control and signal wiring in the AFD that connects external wiring to the AFD shall be twisted shielded pairs and shall be separated from any AFD wiring that may contain voltage and/or current harmonics inherent in inverter operation by not less than 4 inches except at 90-degree crossings.

C. Conductor Markers: Markers used for identification shall comply with the requirements of Specification 16050.

D. Terminations and Cable Connections:

1. Terminals: Control wiring shall be lugged with ring-tongue or locking spade crimp type terminals made from electrolytic copper, tin-plated. All control wiring shall be terminated on separate terminal blocks within the AFD enclosure.
2. Cable Connectors:
 - a. Cable connectors for use with stranded copper wire, sizes No. 8 AWG to 1000 kcmil, shall be UL listed. Dished conical washers shall be used for each bolted connection. Connectors shall be reusable and shall be rated for use with copper conductors.
 - b. Motor feeder cables shall terminate directly on the AFD load terminals. Termination lugs shall have adequate dedicated space for the type and size of conductors indicated on the Drawings. The lugs shall be compression type with anti-turn feature.

E. Control Devices: Control devices such as pushbuttons, selector switches, and indicating lights shall be mounted on the unit compartment door. The control devices shall comply with the requirements of Specification 16300.

F. Nameplates: Nameplates shall be provided in accordance with the requirements of section 16010.

2.3 ADJUSTABLE FREQUENCY DRIVES

A. Input Power:

1. AFDs shall be self-adjusting to accept an input voltage range between 380 volts AC to 480 volts AC, three phase, ± 10 percent.
2. Displacement Power Factor:
 - a. Six-Pulse AFD: 0.95 or better at rated load and nominal line voltage over the entire speed range.
 - b. Eighteen-Pulse VFD: 0.98 or better at rated load and nominal line voltage over the entire speed range.
3. Efficiency: Efficiency including control power supplies, control circuits and cooling fans shall be 96.5 percent minimum at full speed and motor load at nominal line voltage.

B. Sizing: AFD nominal rated output shall be as required to continuously drive the specified the motor load under the conditions specified herein.

1. Variable Torque (Normal Duty): AFD shall be rated to provide 110 percent overload capability for up to one minute and 150 percent for up to three seconds.
2. Constant Torque (Heavy Duty): AFD shall be rated to provide 150 percent overload capability for up to one minute and 180 percent for up to three seconds.
3. The ampere rating of the AFD, adjusted in accordance with the AFD manufacturer's published guidelines for the environmental conditions specified in paragraph 16269-1.5 and the mounting and enclosure requirements specified in paragraph 16269-2.2, shall exceed the associated motor nameplate full load current rating.
4. Speed Range: AFDs shall be rated to operate the specified load to a maximum speed of 60 hertz unless otherwise indicated in Table 16269-A.

C. The AFD shall remain on line and operate without damage to either the AFD or its connected load during a supply power dip of 20 percent of nominal.

D. Disconnect and Line Fuses: A door-interlocked, non-fused disconnect switch with flanged-mounted, lockable operating means shall be provided. Fast-acting drive branch circuit fusing shall be provided for protection against internal faults and as a backup for external load faults. Load faults shall normally be cleared by the inverter assembly. At the Contractor's option, a molded case circuit breaker may be provided in lieu of the disconnect and line fuses at no additional cost to the Owner.

Disconnect switch or circuit breaker mechanism shall be provided with an auxiliary contact to serve as a disconnect means for any foreign control voltage source within the AFD enclosure.

- E. AC Line Reactors: The AFD shall be provided with 5 percent impedance, AC series line reactors for protection against spikes and surges without the requirement for an external isolation transformer. Series line reactors shall be provided on the input power source to the AFD rectifier downstream of the AFD disconnect switch and shall be mounted in the AFD compartment.
- F. Rectifier: The rectifier shall consist of a full wave, 3 phase, diode bridge or SCR bridge rectifier to convert the incoming fixed voltage/frequency to a fixed DC voltage.
- G. Inverter: Inverter section shall consist of latest generation insulated gate bipolar transistors and shall not require commutation capacitors.
- H. Control Power Transformer: Fused control power transformer rated to serve the AFD control power requirements plus 250 VA spare capacity. Control power transformer shall provide control and operating power for AFD control systems and specified peripheral systems. Control and power circuits shall be individually fused.
- I. Protective Features:
 - 1. Overcurrent Protection: The AFD system shall provide electronic current limit protection. Current limit shall be accurate to within 1.0 percent and shall smoothly limit motor speed at whatever value is necessary to limit motor current to that value.
 - 2. AFD shall provide electronic motor overload protection tested in accordance with UL Standard 991 to meet the requirements of the National Electrical Code. Overload protection shall be speed sensitive and variable for motors with speed ranges of 2:1, 4:1, and 10:1.
 - 3. Short Circuit Protection: The AFD shall be fully protected against load faults. Bolted faults, phase to phase or phase to ground shall not damage the unit. Fault protection shall be based on a power source short circuit capacity of 65,000 amperes RMS symmetrical at the AFD power input terminals. Any impedance or other current limiting devices necessary to meet this requirement shall be provided as part of the AFD system. Any additional losses caused by current limiting devices shall be included in the efficiency calculation for the AFD system.
 - 4. Line Voltage: The AFD shall be protected against high and low line voltage on one or more phases. AFD shall be provided with phase-to-phase and phase-to-ground metal oxide varistor (MOV) transient surge protection.
 - 5. Internal Faults: The AFD shall incorporate an internal fault monitoring system to detect malfunctions. This system shall be designed to protect the AFD from transient and sustained faults and to limit damage that may be caused by these faults.

6. Motor Winding Overtemperature Protection: AFD shall accept five positive temperature coefficient (PTC) thermistor inputs.

J. Fault/Diagnostic Announcer: The AFD shall be provided with a fault/diagnostic message annunciation system which shall indicate the cause of any shutdown. Announcer shall identify the first fault in those cases where multiple faults occur between manual or automatic resets and shall be visible without opening the AFD cabinet. Announcer shall present all diagnostic and fault information. As a minimum, the following faults shall be annunciated:

1. Power loss.
2. Undervoltage.
3. Overvoltage.
4. Motor overload.
5. Heat sink overtemperature.
6. Maximum retries.
7. Phase-to-phase and phase-to-ground faults.

K. Programmable AFD Features: AFD control logic shall be microprocessor-based for control of drive control logic functions and drive operating parameters including frequency, voltage and current. Drive setup and operating parameters shall be digitally programmable from the AFD display and programming panel located on the enclosure door. All setup and operating parameters shall be stored in nonvolatile memory (EEPROM). Programmable features shall include the following:

1. Minimum/maximum output frequency limits.
2. Independent timed linear acceleration and deceleration functions, 0 to 600 seconds.
3. Configuration of volts per hertz for squared, cubed, straight line or full custom patterns.
4. Current limit from 20 to 160 percent of constant torque rating. Current limit shall be active for all AFD states; accelerating, constant speed, and decelerating. The AFD control logic shall employ proportional-integral regulation for smooth transition in and out of current limit.
5. Variable carrier frequency (2 to 8 kHz) and three bands of critical frequency avoidance lockout with variable bandwidth and center frequency.
6. Speed regulation modes including:
 - a. Open loop.
 - b. Slip compensation with 0.5 percent speed regulation.
 - c. Droop-negative slip compensation.

- d. Traverse function.
- e. Phase lock loop.
- f. Closed loop encoder feedback with 0.1 percent speed regulation.

7. DC boost function providing a selectable range for offsetting motor losses at low frequency operation. DC boost shall be current regulated and shall automatically adjust, on each start, to motor temperature and load changes. Variable from 15 percent to 120 percent of drive current rating.
8. Selectable automatic restart following restoration of power following an outage.
9. Selectable automatic fault reset and restart up to nine fault occurrences.
10. Flying start providing the capability to start into a spinning motor without tripping.

L. Control Interface:

1. Human Interface Module (HIM): The AFD system shall be provided with a removable, door-mounted HIM consisting of an alphanumeric, backlit LCD display and sealed keypad to facilitate viewing and programming of drive setup and operating parameters including drive fault annunciation. The HIM shall be removable under power without causing a drive fault and be visible and operable without opening the enclosure door. As a minimum the following operating parameters shall be displayed on the HIM:
 - a. Output voltage.
 - b. Output current.
 - c. Output frequency.
 - d. Power demand, kilowatts.
 - e. Elapsed time.
2. Operator Control Devices: Operator control devices shall be provided on the front door of the AFD enclosure. The operator control devices shall be discrete, industrial-grade operator interface components or, alternatively, the same functions may be provided through the display and programming panel. The operator control functions shall be as indicated on the Drawings and include the following:
 - a. Hand-Off-Remote Selector Switch
 - b. Start-Stop Pushbutton
 - c. Drive Reset Pushbutton
 - d. Drive Ready Indicator
 - e. Drive Run Indicator
 - f. Overtemperature Fault Indicator

- g. Overtemperature Fault Reset Pushbutton
- h. Drive Output Frequency Control

The control devices shall be front mounted on the AFD enclosure between 36 inches and 72 inches above the floor.

- 3. Data Communication Interface: AFD shall be provided with a single point interface to permit data communication via an EtherNet/IP network to both the AFD and any ancillary EtherNet/IP-ready devices located in the AFD enclosure. The data communication interface shall permit discrete transfer of operating and speed control commands to the AFD as well as return the AFD operating status. All AFD programmable setup parameters shall be read and write accessible through the communication interface. The data communication interface shall derive required operating power from the AFD system or communications link. No external power source shall be required.
- 4. Hardwire Control Interface: AFD hardwire control interface shall be rated for 120 volt AC operation. A control interface card shall provide access to fixed AFD functions including start, stop, remote auxiliary, speed select, enable, reverse, jog, and local control selection. Inputs shall be programmable to configure the AFD for standard 3-wire, 2-wire, and serial operation requirements. The control interface provided for fixed AFD functions shall be optically isolated from the AFD control logic and shall require 10 mA of power per input.

The external hardwire control and monitoring interface shall conform to the control diagrams presented in the E-series Drawings and to the requirements specified herein.

Each engineered AFD system shall be provided with a specific hardwire interface to establish the specified control interlocks with associated support systems and to control and communicate additional AFD operation parameters not accessible through the AFD serial communication interface or the AFD fixed function interface.

Hardwire interface functions shall include, but not by way of limitation, the following:

- a. AFD Start: Contact closure input to initiate drive operation. Upon closure, the drive shall ramp the load to the higher of the minimum speed setting or the operating speed setpoint established by the speed reference signal.
- b. AFD Stop: Contact closure input to initiate drive shut down. Upon opening, the drive shall coast to a stop.
- c. AFD Speed Select: Contact closure input to select one of two programmed speed reference signal sources.
- d. AFD Jog: Contact closure input to initiate drive operation for the duration the contact input is closed.
- e. Drive Enable: Contact closure input to function as a permissive signal for drive operation.

- f. Drive Auxiliary: Contact closure input to function as a permissive signal for drive operation. Interruption of drive auxiliary signal shall be handled as a drive fault condition.
- g. Drive Fault: Form “C” contact closure output to indicate a drive fault condition.
- h. Drive Run – Normally open contact closure output to indicate a drive run condition.

Refer to the control diagrams in the E-series Drawings for additional system interface requirements.

- 5. Remote-Mounted Human Interface Module Kit: Where scheduled in Table 16269-A, the AFD shall be provided with a remote-mounted HIM kit consisting of the following:
 - a. HIM: HIM shall be of similar functionality to the HIM provided at the AFD and shall be suitable for remote mounting on the door of an industrial enclosure. HIM sealing rating shall be NEMA 4X.
 - b. Screw-Terminal Adapters: Two screw terminal adapters shall be provided for interfacing the field installed communication cable to the HIM and the communication port at the AFD.
 - c. Communication Cable: Communication cable as recommended by the AFD manufacturer of a length suitable for each application.

PART 3 - EXECUTION

3.1 INSTALLATION OF VARIABLE FREQUENCY DRIVES

- A. AFDs shall be installed in accordance with the requirements of Specification 16010 and as indicated on the Drawings.

3.2 FIELD QUALITY CONTROL

- A. General: Prior to energization of electrical circuitry, check all accessible connections to manufacturer's tightening torque specifications.
- B. Configuration and Startup: Provide the services of a qualified factory-trained manufacturer's representative to assist the installing contractor with the installation, configuration and startup of each AFD. The manufacturer's representative shall inspect the installation of each AFD and configure each AFD for operation under the specified conditions. The manufacturer's representative shall conduct the initial startup and operation of each AFD.

C. Certification: A factory-trained manufacturer's representative shall certify in writing that each AFD system has been installed, configured, and tested in accordance with the manufacturer's recommendations.

3.3 TESTING

A. General: Each AFD shall be field acceptance tested in accordance with Section 16010 and 16050.

3.4 TRAINING

A. The Contractor shall provide the services of a factory-trained instructor for the purpose of training the Owner's personnel in the proper operation and maintenance of the AFDs. Training shall consist of not less than 4 hours of field instruction in the operation, testing, troubleshooting, and maintenance of the transfer switch in accordance with Section 01820.

3.5 ADJUSTABLE FREQUENCY DRIVES SUMMARY

A. The Adjustable Frequency Drives Summary, Table 16269-A, is appended to the end of this specification section. The entries in the drives summary are defined as follows:

1. AFD Number: Unique identification number assigned to the AFD.
2. Equip Number: Identifies the driven equipment associated with the AFD.
3. Description: Description of the driven equipment associated with the AFD.
4. Motor/HP: Nominal horsepower rating of the motor to be furnished with the driven equipment.
5. Motor/RPM: Synchronous speed of the motor to be furnished with the driven equipment.
6. Load Type: Load characteristic of the driven equipment.
 - a. Variable Torque: AFD rating shall be Normal Duty.
 - b. Constant Torque: AFD rating shall be Heavy Duty.
7. Control Diagram: Identifies the control diagram associated with the AFD.
8. Mounting/Enclosure Rating:
 - a. Wall: AFD shall be installed in a wall-mount enclosure system.
 - b. Freestanding: AFD shall be installed in a freestanding enclosure system.
 - c. Open: AFD shall be provided as an open chassis assembled on mounting panel suitable for installation in a third party enclosure.
9. Notes: Provides additional reference information.

END OF SECTION

Table 16269-A
Adjustable Frequency Drives Summary

AFD Number	Equip Number	Description	Motor		Load Type	Control Diagram	Mounting/Enclosure Rating	Notes
			HP	RPM				
VFD 1	#	Pump 1301	20	1800	Constant Torque	#	Wall/NEMA 1	
VFD 2	#	Pump 1302	20	1800	Constant Torque	#	Wall/NEMA 1	
VFD 3	#	Pump 1303	20	1800	Constant Torque	#	Wall/NEMA 1	